ON

LONG, SHORT, AND WEAK SIGHT,

AND THEIR TREATMENT

BY

The Scientific Use of Spectacles.

BY

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TO

WILLIAM BOWMAN, Esq., F.R.S.,

ETC., ETC.,

THIS VOLUME IS DEDICATED,

AS A

SLIGHT TRIBUTE OF ADMIRATION FOR HIS EMINENT PROFESSIONAL ATTAINMENTS,

AND OF

GRATITUDE FOR HIS UNVARYING KINDNESS AND FRIENDSHIP,

BY

THE AUTHOR.

PREFACE.

I have endeavoured in these pages to lay before the reader, in an easy and practical form, the modern theories of the affections of the Accommodation and Refraction of the Eye, so as to enable him at once to grasp the most salient and important points in the symptoms, diagnosis, and treatment of these diseases. I have purposely abstained from mathematical calculations, and have confined myself to such simple formulæ as I have found most serviceable and ready in practice.

I have chiefly followed the views of Von Græfe and Donders in treating of these affections; indeed, we are mainly indebted to their admirable and important researches for the scientific elucidation and treatment of this class of eye diseases.

The substance of this work appeared last year in the "Medical Times and Gazette," in a series of

papers, entitled "Practical Hints on the Accommodation of the Eye; its Anomalies, and their Treatment." The favourable reception accorded to them has encouraged me to republish them in a separate form; and in order to render them as complete as possible, I have added considerably to the original matter, and have entered more fully into several important subjects—*e.g.*, The Accommodation of the Eye, Sclerotico-Choroiditis Posterior, Asthenopia Dependent upon Insufficiency of the Internal Recti Muscles, &c. I have also illustrated the text with several explanatory wood-cuts, and given two lithographic plates, showing the anatomical relations of the parts concerned in accommodation.

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March, 1862.

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ON

LONG, SHORT, AND WEAK SIGHT

AND THEIR TREATMENT BY THE

SCIENTIFIC USE OF SPECTACLES.

CHAPTER I.

THE ACCOMMODATION OF THE EYE.

By the term accommodation is meant the power which every normal eye possesses of adjusting itself almost imperceptibly and unconsciously to different distances. At one moment looking at something but a few inches from the eye, at the next regarding some far distant object, or taking in at a glance the vast expanse of miles of scenery.

In a normal eye the whole apparatus of accommodation is so beautifully balanced, its functions performed with such ease and accuracy, that, although in reality a voluntary act, its duties are from early childhood fulfilled intuitively, unconsciously. No wonder, then, that this power of adjustment of the eye to different distances has been a favourite study with some of the most eminent physiologists and natural philosophers.

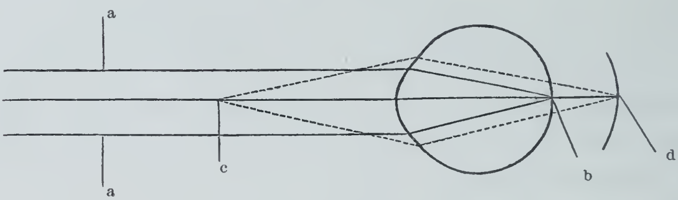
That such a power is essentially necessary will become at once apparent by a consideration of the following fact, and a glance at Fig. 1.

Let us assume that the normal eye when in a state

of rest is adjusted for objects at an infinite distance* (rays from which may be considered as being parallel), *i.e.*, rays emanating from such an object are brought to a focus upon the retina without any effort of accommodation. But when the object is brought much nearer, the rays from it will become divergent, and will now be no longer focused upon the retina, but behind it, if the eye does not undergo some change which will increase its refraction and unite these divergent rays upon the retina.

The accompanying figure will explain this: it represents a normal eye in a state of rest, so that

Fig. 1.



parallel rays (a), emanating from an object at an infinite distance (at or beyond 18 feet from the eye) are brought to a focus upon the retina (b), without any

* As the term infinite distance will necessarily constantly recur in these pages, it will be well to explain its signification at the outset. We consider an object to be at a *finite* distance as long as rays emanating from it fall in a divergent direction upon the eye. Of course rays from even a very distant object do in reality diverge, but this divergence (which naturally decreases in extent the further the object is removed) is already so slight, when the object is placed at a distance of 18 or 20 feet, that the rays from it impinge, to all intents and purposes, parallel upon the eye; and we therefore consider rays coming from an object further than 18 feet as parallel, and as emanating from an object at an *infinite* distance. Rays coming from a nearer object are divergent in proportion to its proximity, and are considered as coming from a *finite* distance.

effort of the accommodation. If the object is now moved much nearer to the eye to c, say 12 inches from the eye, the rays from it will be strongly divergent, and will be brought to a focus behind the retina at d, if the eye does not undergo some change in form (becoming proportionately longer), or if its power of refraction be not increased by some change in its apparatus of refraction, so that the rays will be united upon the retina. For if this is not the case, and the rays are united *behind* the retina, circles of dispersion will be formed upon the latter, and the object appear blurred and indistinct.

It has long been a keenly debated question in what the changes of accommodation of the eye consist, and various opinions have been advanced. Some thought that the cornea underwent some alteration during accommodation for near objects, so that its power of refraction was increased, and the eye enabled to adjust itself for reading, writing, &c.; but, apart from other reasons against this theory, Helmholtz has shown, with his ophthalmometer, that there is no alteration in the curvature of the cornea during accommodation.

Others have supposed that the muscles of the eyeball play an important part in bringing about, in conjunction with the ciliary muscle, the adjustment for near objects. Arlt, one of the warmest supporters of this theory, says:—"The accommodation or adjustment of the eye for near objects is brought about by the elongation of the eyeball in the optic axis, by the pushing back of the posterior wall of the eyeball, by the retrogression of the yellow spot and its vicinity. The organs causing this are, on the one hand, the straight and oblique muscles of the eye; on the other, the ciliary

muscle—they being simultaneously placed in a higher state of tension," &c.*

That the act of accommodation for near objects is not due to the action of the external muscles of the eyeball is, however, proved in an incontrovertible manner by a case of Von Græfe's, in which all the recti and obliqui muscles of both eyes were paralysed, so that the eyes were completely immovable, and yet the power of accommodation was perfect.

It has at length, however, been definitely settled, chiefly by the experiments of Cramer and Helmholtz (conducted independently of each other), that the necessary change in the refraction of the eye during accommodation is due to an alteration in the form of the crystalline lens. Helmholtz found, by means of his ophthalmometer, that the lens did not change its position during accommodation for near objects, but that this was brought about by a change in the curvature of the anterior and posterior surfaces of the lens, which become more convex (the lens itself thicker from before backwards), so that the lens acquires a higher power of refraction, and consequently a less focal distance, by which means rays from even very near objects are brought to a focus upon the retina. He found, with the ophthalmometer, that the eye undergoes the following changes during accommodation for near objects :

1. The pupil diminishes in size.
2. The pupillary edge of the iris moves forwards.
3. The peripheral portion of iris moves backwards.
4. The anterior surface of the lens becomes more convex (arched), and its vertex moves forwards.

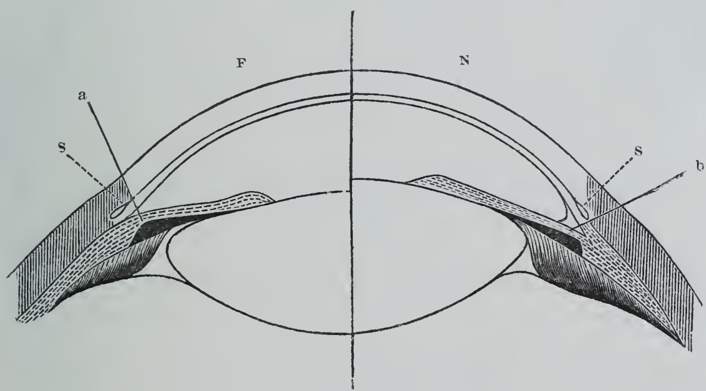
* Arlt, vol. 3, 207.

5. The posterior surface of the lens also becomes slightly more arched, but does not perceptibly change its position. The lens therefore becomes thicker in the centre.

As the volume of the lens must remain the same, he thinks that we may, moreover, assume that the transverse diameter of the lens becomes diminished. He finds, from calculation, that these changes in the lens are quite sufficient for all accommodative purposes.

Fig. 2* illustrates the changes which the eye undergoes during accommodation. The anterior portion of

FIG. 2.



the eye is divided into two equal parts. The one half, F, shows the position of the parts when the eye is adjusted for distance, the other, N, when it is accommodated for near objects. When the eye is in a state of rest, the iris forms a curve (a) in the vicinity of Schlemm's canal (s); when accommodated for near objects, the fibres of the iris become contracted, the periphery of the iris straightened (b), and the anterior chamber lengthened, thus making up for its loss in

* Helmholtz.

depth, through the advance of the anterior surface of the lens.

There being now no doubt that the accommodation of the eye is due to a change in the form of the lens, the next question is, by what means is this change produced? and this brings us to the consideration of the much debated, but yet unsettled question of the mechanism of accommodation.

The combined action of the iris and ciliary muscle have been considered the chief factors of this change in the form of the lens, some giving the pre-eminence to the iris, others to the ciliary muscle. Before entering into this question, it will be well just to glance at the anatomical position of the parts involved, by referring to Figs. 3 and 4.*

Description of Lithographic Plates.

Fig. 3.

Horizontal section of the human eye, × 5.

S. Sclerotic.

s c. Sclerotic conjunctiva.

s c′. Epithelium of the same.

C. Cornea.

c c. Its anterior elastic lamina, passing over from the layer of connective tissue of the sclerotic conjunctiva.

c c′. Epithelium of the anterior surface of the cornea.

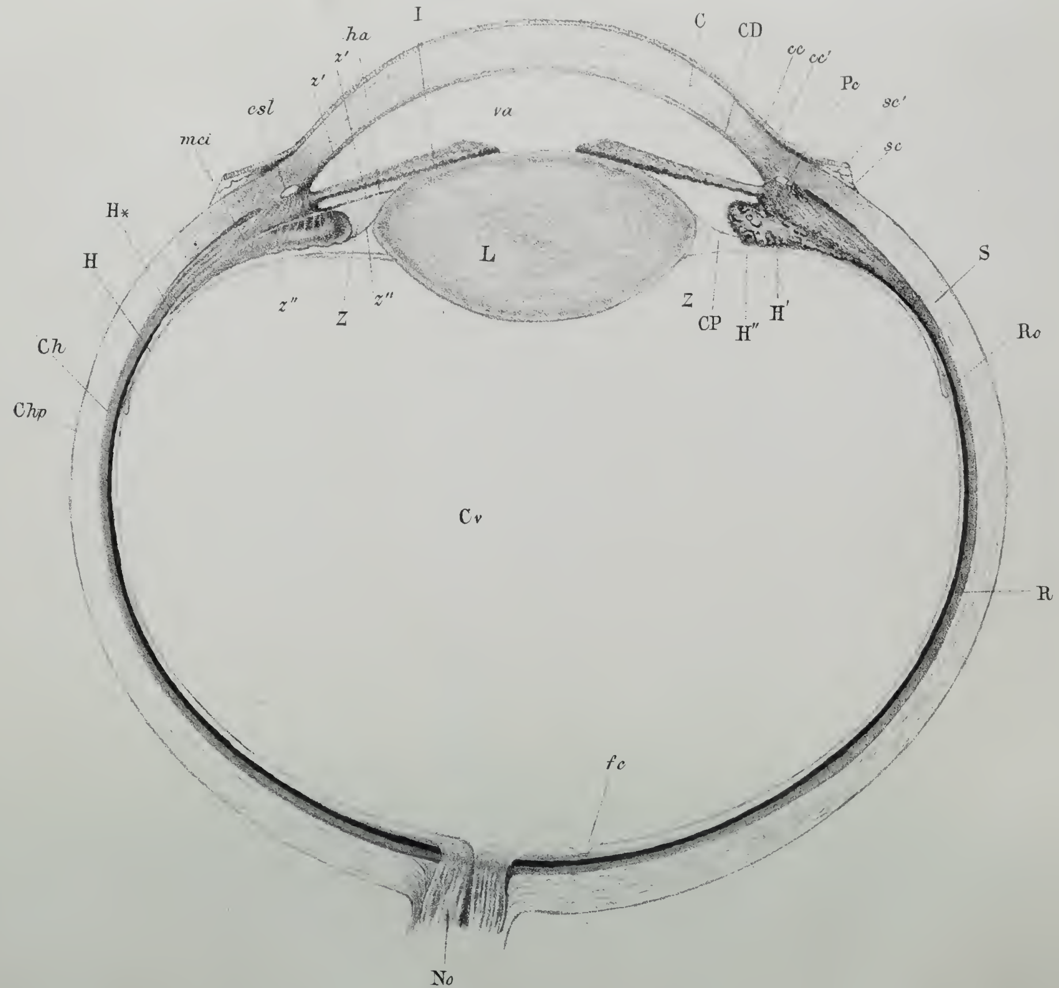
C D. Membrane of Descemet.

c s l. Canal of Schlemm (circular sinus).

The sclerotic, when denuded of conjunctiva, is thinner than the cornea. As the conjunctiva becomes

* Copied from Ecker's beautiful "Icones Physiologicæ."

Fig. 5.



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No

rapidly thinned at the spot where the sclerotic passes over into the cornea, the sclerotic appears to be constricted at the place of transition.

Ch. Choroid.

Ch p. Its pigment layer.

P c. Ciliary processes. On the right side the section is carried through the ciliary process. As the surface of the latter is uneven and nodulated, the edge of the section appears scalloped. On the left side the section is carried between two ciliary processes—the process may be seen sticking in the fold of the zonula. The ciliary processes do not reach quite up to the lens, but remain about half a millimetre distant from its equator.

m ci. Ciliary muscle (for whose origin and course vide Fig. 4).

I. Iris. This is thinnest at its origin, becoming thicker towards the edge of the pupil, towards which it is bevelled off.

R. Retina.

R o. Ora serrata.

N o. Optic nerve.

f c. Fovea centralis (yellow spot).

H. Hyaloid.

H*. Place of its division into two laminæ. About one line from the ora serrata, the hyaloid lies close against the external tunics (retina), and from thence passes on free towards the lens. Here, therefore, the division occurs. The elevation of the ciliary processes does not, however, take place till about one line further forwards.

H′. Anterior layer of the hyaloid passing over the

ciliary processes (zonula Zinnii). Now, as this layer covers the ciliary processes, it must, of course, assume a folded appearance.

The ciliary processes, as far as they extend, are set in the folds of the zonula ; but from the spot where the ciliary processes cease, the folded zonula (Z) (whose folds are now, however, empty, less deep, and—because the circumference of the lens is smaller—plaited more closely together) passes on to the edge of the capsule of the lens, to which, blending with it, it attaches itself. On the left side, where the section passes between two ciliary processes, the two layers of the zonula-fold (z' z'') between which the ciliary process lies, may be observed ; it is also seen how this fold passes on (empty) beyond the ciliary processes to the lens. It is evident, therefore, that the line of junction which the zonula (folded in plaits) forms at the capsule corresponds to the cross section of a plait, and consequently assumes a wavy appearance.

H″. The posterior lamina of the hyaloid ; this is attached behind the æquator of the lens, and forms the posterior wall of the canal of Petit.

C P. Canal of Petit.

L. Lens.

C v. Vitreous humour.

v a. Anterior chamber.

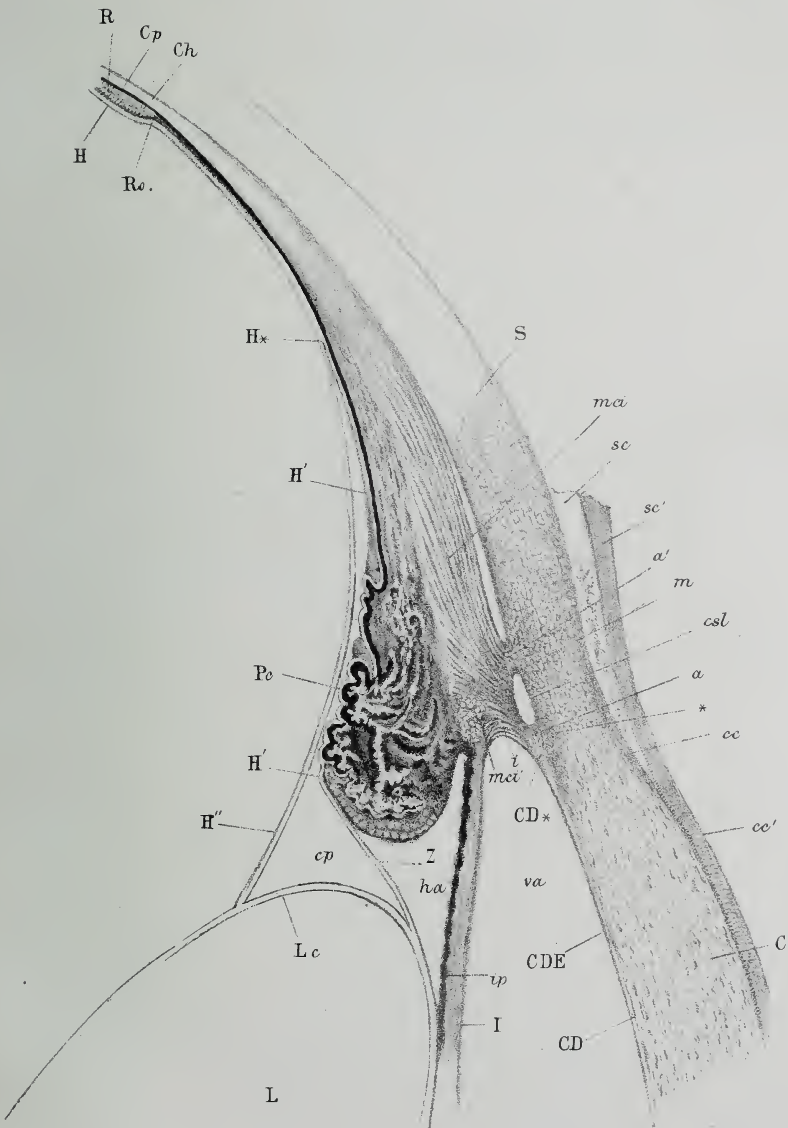
h a. Posterior chamber.

Fig. 4.

Section of the parts of the human eye concerned in accommodation × 15.

C. Cornea.

Fig. 4.



R
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c c. Its anterior elastic lamina passing over from the layer of connective tissue (s c) of the sclerotic.

c c′. Epithelium of the anterior surface of the cornea.

C D. Membrane of Descemet; its homogeneous lamella.

C D E. Its epithelium.

S. Sclerotic.

s c. Vascular layer of connective tissue of the sclerotic conjunctiva.

s c′. Its epithelium.

The tissue of the cornea passes over into that of the sclerotic without any well-defined boundary. The place of the caudated corneal corpuscles is gradually supplied by elastic meshes, and that of the homogeneous corneal plates between them by layers of fibrous connective tissue. The elastic meshes are particularly close together in the vicinity of Schlemm's canal, running here also, by preference, in a circular direction.

c s l. Canal of Schlemm.

In the vicinity of this canal (at C D*) the homogeneous lamina of the membrane of Descemet splits up into a number of fibrous plates, which appear first at the outer side, so that the membrane of Descemet seems to terminate with its edge bevelled off towards the inner side. These fibres, whose character appears to lie midway between the elastic and fibrous connective tissue, are thus distributed: (1), the external (a) pass over into the elastic meshes of the sclerotic, and particularly into the external wall of Schlemm's canal; (2), the middle fibres (m) serve as an origin for the ciliary muscle; (3), the most internal (i), forming the ligamen-

tum pectinatum (pillars of the iris), are connected with the iris.

Ch. Choroid.

C p. Its pigment layer.

P c. Ciliary process (a longitudinal section).

On account of its uneven, nodulated surface, the section of the tissue appears at one place edged with pigment, and at another deeper portions of the surface appear not touched by the section.

m c i. Ciliary muscle ; its fibres run in a wavy manner, the greater portion of them lying in the direction of the meridians, and can be easily peeled off. When these have been removed, other fibres are also seen to run in a transverse direction (m ci′).* It is probable that the one set bend round and pass over into the other, thus forming arcades. This has not, however, yet been ascertained with certainty.†

I. Iris.

i p. Pigment layer.

In the substance of the iris radiating fasciculi of connective tissue are seen.

* Circular fibres of Müller.

† The following is Kölliker's description of the ciliary muscle: "The ligamentum ciliare of anatomists, called also musculus ciliaris or tensor choroidea, was recognised as being of a muscular nature, almost simultaneously, by Brücke and Bowman ; it is a tolerably thick lamina of radiating smooth muscular fasciculi, which pass from the most anterior border of the sclerotic to the corpus ciliare, and are lost in the anterior half of that body, at the spot corresponding to the situation of the ciliary processes internally. More accurately described, the ciliary muscle arises at that part of the sclerotic where it is furrowed for the formation of the venous sinus of Schlemm (*vide* Fig. 4, c s l); indeed, it is from a special dense, smooth tract, which, whilst forming the inner wall of the abovementioned canal, coalesces with the sclerotic, receiving at the same

R. Retina.
R o. Ora serrata.
H. Hyaloid.
H*. Place of its division.
H′. Zonula.
Z. Its free portion.
H″. Posterior lamina of the hyaloid.
c p. Canal of Petit.
L. Lens.
L c. Capsule of lens.
v a. Anterior chamber.
h a. Posterior chamber.

Cramer supposed that the arching forward of the lens was caused by the iris, its dilatator and sphincter being simultaneously contracted, the peripheral portion of the iris at the same time moving backwards, by which means a certain amount of pressure was exerted upon the peripheral portion of the lens which is covered by the iris, in consequence of which pressure the anterior surface of the lens must become more arched. The

time a part of the fibrous networks prolonged from the membrane of Desmours; the last-mentioned fibres coalesce perfectly with the similar elements of the special tract, which are, however, finer, anastomose more densely, and have a circular direction. The termination of the ciliary muscle is at the attached part of the ciliary processes, but not in these structures themselves. The muscular elements are somewhat shorter (0·02‴) and broader (0·003‴ to 0·004‴) than the ordinary fibre cells, and are finely granular and very delicate; they are, indeed, so perishable, that they cannot be easily isolated in the human subject. Very lately, H. Müller has discovered a circular muscular layer, quite anteriorly beneath the radiating fibres of the ciliary muscle; and this I call the circular muscle of Müller. The latter forms the deepest and most anterior layer of the ciliary muscle close to the insertion of the iris."

simultaneous tension of the radial and circular fibres of the iris having the effect of decreasing the pressure in the anterior chamber, and increasing that in the vitreous. He thinks that the ciliary muscle acts in so far that it prevents the lens being pushed backwards under the pressure of the iris, and that it defends the retina from deleterious pressure.

Donders agrees on the whole with these opinions, but thinks, also, that the ciliary muscle, by drawing the peripheral edge of the iris backwards against the wall of the canal of Schlemm, forms a fixed point for the action of the dilatator pupillæ. This would form the posterior fixed point, the anterior being formed by the contracted sphincter pupillæ. Donders, moreover, vindicates the importance of the ciliary muscle during accommodation, for he says, "I consider this muscle (ciliary muscle) just as important for the change in the form of the lens as the muscular fibres of the iris. Without it the iris would not be able to exert a pressure of any importance upon the lens."

Helmholtz shows, however, that although these theories of Cramer and Donders suffice to explain the arching forward of the anterior surface of the lens, they do not suffice for the explanation of the whole change in the form of the lens which occurs during accommodation for near objects. Heinrich Müller gives the following very clear *resumé* of Helmholtz views :—"Finally, Helmholtz thinks with Donders that the iris, in conjunction with the ciliary muscle, is the chief organ of accommodation. He, however, believes that the recession of the peripheral portions of the iris may also be explained by the tension of the dilatator, the latter level-

ling the iris, which was before slightly bent, (vide Fig. 2) by the action of the elastic fibres of the ligamentum pectinatum (pillars of the iris), and laid along the whole breadth of the canal of Schlemm against the inner wall of the latter. Besides this, Helmholtz also assumes that the ciliary muscle not only draws the insertion of the iris backwards, but also draws the posterior ends of the ciliary processes forwards, thus causing a relaxation of the zonula, which in its turn again favours the increase in the thickness of the lens."

Heinrich Müller attaches far greater importance to the action of the ciliary muscle than to the iris. He, moreover, discovered that the ciliary muscle consists of two different sets of fibres—a radiating longitudinal and a circular. (Vide Fig. 4, m c i, and m c i′.)

He ascribes a different action to each set of fibres, and has come to the following conclusions as to the probable action of the different parts concerned in accommodation. He thinks that*—

1. "The circular fibres of the ciliary muscle exert a pressure upon the edge of the lens, by means of which the latter becomes thicker.

2. "The longitudinal fibres of the muscle cause an increase of tension in the vitreous humour, on account of which the posterior surface of the lens is prevented from shifting, and the action of the peripheral pressure is chiefly confined to the anterior surface.

3. "The pressure of the tense iris on the peripheral portion of the anterior surface of the lens assists in increasing the convexity (arching forward) of the latter, and in preventing the arching of the posterior surface.

* Von Græfe's Archiv., III., 1, 23.

4. "The arching forward of the centre of the anterior surface of the lens is rendered possible and favoured by the recession of the peripheral portion of the iris, which is accompanied with a contraction of the deeper (circular) layer of the ciliary muscle and the iris.

5. "The contraction of the ciliary muscle causes finally a relaxation of the anterior portion of the zonula, by which means again the increase in the thickness of the lens is promoted."

We have shown how Cramer, Donders, Helmholtz, Müller, as well as many other observers, have considered the iris to play a more or less important part in the mechanism of accommodation. It was difficult, indeed impossible, to determine with accuracy the relative amount of importance of the iris or ciliary muscle even after the most careful dissections and most elaborate investigations. This question as to the importance of the iris in accommodation has, however, been set at rest most thoroughly by a case which occurred in Von Græfe's clinique about two years ago, and which has proved of the greatest importance in settling this question. The following is the history of the accident :—

"Carl S., a locksmith, 27 years of age, was injured, on the 30th November, 1859, by a chip of metal which flew against his right eye, This was at once followed by dimness of vision and violent pain, the latter soon yielded to cold applications, a slight sensation of pressure only remaining, the former partially persisted. On his presenting himself at the clinique the next day, I found a tolerably large prolapse of the iris near the outer edge of the cornea, including the edge of the iris, the pupil being correspondently displaced. Vision was

somewhat impaired, on account of the abnormal curvature of the cornea after the prolapse of the iris, and on account of a slight infiltration of the cornea. The patient was placed in bed, atropine dropped in, and the lids closed with plaister. On the fourth day after the accident, the prolapse was considerably swollen, and I proceeded to abscise it (contrary to my usual practice) with a pair of scissors.* Whilst the scissors were cutting, the patient made a sudden violent movement with his head, which the assistant could not check; the iris was somewhat dragged, and a dialysis occurred at the opposite side. The patient was at once placed in a recumbent position, and the portion of the iris still lying between the lips of the wound was drawn gradually out until the dialysis was complete. The removed portion of iris being spread out, it was thus ascertained that the whole iris had been removed. The slight effusion of blood soon disappeared from the anterior chamber; indeed, I have generally noticed that the bleeding lasts a shorter time in total dialyses than when they are partial (perhaps on account of the incomplete separation of the bloodvessels at the edge of the hiatus which occurs in the latter case). Ten days after the operation the cornea had also regained its transparency.

"On examining the eye with the ophthalmoscope, the denuded ciliary processes could be seen in all

* Græfe generally, in abscising a prolapse of the iris, first punctures it with the point of a cataract knife, allows the aqueous humour to flow off, and then, seizing the collapsed iris with a straight pair of iridectomy forceps, snips it off. In this way the size of the lumen can be more accurately determined, and the danger of causing a dialysis of the iris is avoided.

directions, between them and the æquator of the lens (on looking greatly to one side) the outlines of the folds of the zonula became visible. The depth of the anterior chamber did not appear, as far as could be judged from the reflex images, to have suffered at all."

The state of vision of this eye may be judged from the following table :—

The patient can count fingers at					..	150	feet.
Read	No.	20	of Jäger	at	..	24	„
„	„	16	„ „	„	..	10	„
„	„	11	„ „	„	..	3	„
„	„	8	„ „	„	..	20	inches.
„	„	4	„ „	„	..	14	„
„	„	2	„ „	„	..	9	„
„	„	1	„ „	„	..	8	„

The latter print (No. 1 "brilliant") with slight difficulty, but with precision, the rest he reads quite fluently.

The power of accommodation of this eye was most accurately and severely tested in several different methods, and it was found that, in spite of the total absence of the iris, his power of accommodation was quite normal (about $\frac{1}{6}$).* Another highly important and interesting fact was, that after the instillation of a strong solution of atropine, the power of accommodation was completely paralysed.

This case proves not only that the changes of accommodation are independent of the presence of the

* For a full account of these experiments I must refer to Von Græfe's account of this case—Archiv., vii. 2, 26.

iris, but also that the action of atropine on the accommodation is independent of it. The ciliary muscle must be the most active agent in both cases. The mode of this action could not be gathered from the position of the ciliary processes, this only appearing certain, that their accurate contiguity to the æquator of the lens is not necessary.

NEGATIVE ACCOMMODATION.

We have assumed that when the normal eye is in a state of absolute rest, parallel rays (emanating from objects at an infinite distance) are brought to a focus upon the retina, and that a positive change of the accommodative apparatus within the eye is only required for objects at a finite distance. But it is thought by some (particularly Weber and Von Græfe) that the eye, when in a state of rest, is adjusted neither for its far nor for its near point, but for a distance between the two, and that adjustment for either nearer or more distant objects necessitates an effort of accommodation. Now, if we call the adjustment for near objects the *positive* accommodation, that for distant objects may be designated the *negative*.

There is hardly a doubt that the active adjustment for great distances (negative accommodation) depends upon a different mechanism to the positive. Von Græfe thinks that, by the help of certain accessory powers (chiefly the external muscles of the eyeball), which exert a slight pressure upon the eye, and flatten the cornea a little, the refraction of the eye is somewhat diminished, and the far point removed still further than when the eye is in a state of absolute rest.

Henke has, however, lately advanced the theory that the negative and positive accommodations are produced by the action of the ciliary muscle, which he would divide into two, according to the direction of the fibres, viz., the "musculus circularis" and the "musculus radialis." He considers their action to be different and antagonistic, and thinks that in accommodation for near objects the circular muscle is contracted, the radial extended, whereas in accommodation for distance the reverse occurs—the radial muscle being contracted, the circular extended.*

The discovery of the circular fibres in the ciliary muscle is undoubtedly of great importance, although some think that their action is almost completely neutralised by the longitudinal fibres. The mechanism of the accommodation could be, indeed, more easily explained if we might assume that the radial and circular fibres were supplied by branches from different nerves, and that they stood in a similar antagonistic relation to each other as the dilatator and sphincter pupillæ.

* "Der Mechanismus der Accommodation für Nähe und Ferne." Henke. Græfe's Archiv., vi. 2, 53.

CHAPTER II.

THE RANGE OF ACCOMMODATION.

When the eye has assumed its highest state of refraction it is accommodated for its nearest point of distinct vision; when its state of refraction is, on the other hand, relaxed to the utmost, it is adjusted for its furthest point.

The power of the ciliary muscle is, however, limited, and consequently the lens is only capable of a certain increase in its convexity, and the accommodation for near objects has therefore also its limit, and the near point cannot be brought nearer than a certain distance to the eye. In normal eyes the nearest point of distinct vision lies at about $3\frac{1}{2}$ to 4 inches from the eye; this varies, however, according to the age of the patient, for, as we shall show afterwards, the near point recedes further and further from the eye with advancing years. For continued work at near objects—engraving, &c.—the near point lies at about 5 inches. Few eyes, indeed, can bear to work for any length of time with the object nearer than this. The furthest point of distinct vision in the normal eye is at an infinite distance (parallel rays).

The distance between the furthest and nearest point of distinct vision is called the territory or range of accommodation. The amount of this range varies, of course, according to the strength and efficiency of the ciliary muscle, the elasticity of the lens, &c.

Donders determines the range of accommodation thus :—" I take the liberty therefore of proposing a standard as a general expression for the range of accommodation. The range of accommodation A (which may be calculated through the distance which p and r, the nearest and furthest extreme point of accommodation, are from the anterior surface of the crystalline lens), is given by the focal distance a of an ideal lens, which, placed upon the anterior surface of the crystalline lens, would afford to rays emanating from the near point a direction as they came from the far point. We must suppose this lens to be a meniscus placed upon the anterior surface of the crystalline, because the accommodation depends almost exclusively upon a change in the convexity of the anterior surface of the lens."* We can easily understand that a may be approximatively found by the formula :—

$$\frac{1}{p}-\frac{1}{r}=\frac{1}{a} \text{ and that } A=\frac{1}{a}$$

Let us illustrate Donders' way of determining the range of accommodation by an example or two, first explaining, however, the following expressions : A means range of accommodation ; r, far point ; p, near point ; ∞, infinite distance ; ′, foot ; ″, inch ; ‴, line.

* Græfe's Archiv., vol. iv. 1.

1. Normal eyes, which can see from an infinite distance up to 4″ from the anterior surface of the crystalline lens, have their far point (r) at an infinite distance (∞), their near point (p) at 5″. In order to find the range of accommodation of such an eye, we apply the above formula, $A=\frac{1}{p}-\frac{1}{r}$. In our case, $r=\infty$, $p=5''$, therefore $A=\frac{1}{4}-\frac{1}{\infty}=\frac{1}{5}$.

2. Let us test the range of accommodation (A) of a short-sighted, or myopic eye. Let us suppose that its far point (r) lies at 8″ from the eye, its near point (p) at 4″, A therefore $=\frac{1}{4}-\frac{1}{8}=\frac{1}{8}$.

3. A presbyopic, or far-sighted eye, having its far point (r) at an infinite distance (∞), and its near point (p) at 10″, has $A=\frac{1}{10}-\frac{1}{\infty}=\frac{1}{10}$

I shall afterwards, when speaking of hypermetropia, mention the best plan of examining the range of accommodation of a hypermetropic eye.

Another very good method for testing the range of accommodation, and also for quickly discovering whether the eye is myopic, hypermetropic, or presbyopic, is the following, which is much practised by Von Græfe.

A convex lens of 6″ or 10″ focus is placed before the eye.* With this lens the patient then reads No. 1 of Jäger, and his far and near point are noted. The far (r′) and near point (p′) thus found stand in such a relation to his real far (r) and near point (p), that the rays coming from

* The lens must be strong in order that the patient may really command his far point, and that the latter may be approximated so much that the minimum of the angle of distinction no longer exerts any influence, amblyopia being therefore excluded.

r′ are refracted by the lens as if they came from r, those from p′ being also refracted as if they emanated from p. With convex 6, r′ would (in the normal eye) lie at 6″ from the eye, for rays from an object at 6″ distance falling on this lens would be rendered parallel by it, and would, consequently, impinge upon the eye as if they came from an infinite distance (the normal far point). The near point (p′) would lie at about $2\frac{2}{3}$″. This varies according to the age of the patient.

The range of accommodation is therefore easily found by the formula $A = \frac{1}{p} - \frac{1}{r}$. The lens, and the distance from the eye (about $\frac{1}{2}$″) is omitted in the calculation.

If (with convex 6) the far point (r′) lies at 6″, the near point (p′) at 3″, $A = \frac{1}{3} - \frac{1}{6} = \frac{1}{6}$

Let us illustrate this proceeding by the following examples.

I. *Myopic eye.* We find that (with convex 6) r′ = 5″, p′ = 3″. The eye is consequently myopic, for it is not adjusted for the normal far point (6″), but for a nearer one, the rays from which impinge in a divergent direction upon the eye :—

$$A = \frac{1}{3} - \frac{1}{5} = 7\tfrac{1}{2}.$$

Now, what glasses will this patient require for infinite distance? By means of our strong convex lens we have changed this eye into a very myopic one, in fact, into a myopia of $\frac{1}{5}$, for we should have to place a concave glass of 5″ focus before convex 6 in order to enable it to see at a distance ; for this concave glass

would render parallel rays so divergent as if they came from 5″ distance. In order to find the proper concave glass for distance, we deduct concave 5 from convex 6. Hence the proper concave glass will be No. 30 for

$$\frac{1}{6}-\frac{1}{5}=-\frac{1}{30}$$

II. *Hypermetropic eye.* With convex 6, $r'=8$, $p'=3''$. The eye is, therefore, hypermetropic, for its far point lies beyond the normal far point (6″).

Its range of accommodation $=4\frac{4}{5}$ for

$$A=\frac{1}{3}-\frac{1}{8}=4\frac{4}{5}$$

Although we can thus very quickly determine the fact that the eye is hypermetropic, and also its range of accommodation, we cannot find with exactitude the requisite convex glass for distance by the same calculation as in the myopic eye; for, as we shall hereafter show, the amount of hypermetropia before and after the paralysis of the ciliary muscle by atropine varies sometimes greatly.

We may test the range of accommodation by means of Von Græfe's wire optometer, but as this requires some exactitude and intelligence on the part of the patient, I find it generally more practical (particularly with hospital patients) to try them with the test-types. If, whilst they are reading No. 1, we move the type a few times, alternately nearer and further from the eye, we can readily ascertain with exactitude the nearest and furthest point of distinct vision.

Von Græfe's optometer consists of a small square

steel frame, across which a number of very fine parallel, vertical wires are stretched. This frame is attached to a brass rod, upon which it is movable, the rod being graduated in inches and feet. One end of the rod is placed against the forehead of the person to be examined, and then the frame is moved to the nearest point at which the individual wires still look clearly and sharply defined; the distance of this point from the eye is read off from the graduated scale, and put down as the near point. The frame is then removed to the greatest distance at which the individual wires still appear sharply defined, and this is noted as the far point; the distance between the latter and the near point is the territory or range of accommodation.

The wires only appear sharply defined when the eye accommodates itself perfectly for them, directly there is the slightest deviation in this (the frame being too near or too far from the eye), the wires seem indistinct, thicker, or as if surrounded by a halo, or even coloured double images of them may appear in the transparent intervals. As a background to the frame, we may use a white wall, or the sky. It will be easily seen how much depends here upon the intelligence of the person examined, upon his appreciation of the distinctness of the wires, and upon the first appearance of their thickening or doubling. It is sometimes almost ludicrous to what a distance persons will maintain that the wires are still distinct and well-defined, and therefore, in examining children and the ignorant, it is better to make them read small print; if they cannot read, we are, of course, obliged to make use of the optometer, or small dots or marks.

We meet with several deviations from the normal accommodation (pareses of accommodation). Thus, for instance, the near point may be normal, but the far point approached nearer than an infinite distance to the eye; this is often mistaken for myopia;—or the far point may be normal, and the near point receded abnormally from the eye; or, again, both near and far point may have changed their normal position, and have become approximated to each other.

We may also meet with a dislocation of the territory of accommodation without any diminution in its range. If we furnish such eyes with glasses which will bring the territory of accommodation back to its normal distance from the eye, their vision will be quite perfect again.

We have before stated that in a normal eye the far point lies at an infinite distance, so that parallel rays are united upon the retina when it is adjusted for its far point. The near point lies at 4 — 5 inches from the eye. But even a near point of 7″ cannot be considered pathological.

Donders classifies eyes according to the furthest point of distinct vision, and distinguishes three categories.

1. *Normal*, or *emmetropic* eyes, in which, when the eye is at rest, parallel rays are brought to a focus on the retina. When the normal eye is in a state of rest, the focal point of its dioptric system is situated on the bacillar layer of the retina.

2. *Myopic*, or *brachymetropic* eyes, which are adjusted, when in a state of rest, for divergent rays. In this case parallel rays are, even when the eye accom-

modates itself for its farthest point, brought to a focus before the retina; so that distinct images are formed on the retina only of those objects, the rays from which impinge divergently upon the eye. In the myopic eye, when in a state of rest, the focal point of the dioptric system lies before the retina.

3. *Hypermetropic* eyes are adjusted for convergent rays. In this case parallel rays are brought to a focus behind the retina when the eye is at rest; for in hypermetropic eyes the focal point of the dioptric system lies, when the eye is in a state of rest, behind the bacillar layer of the retina.

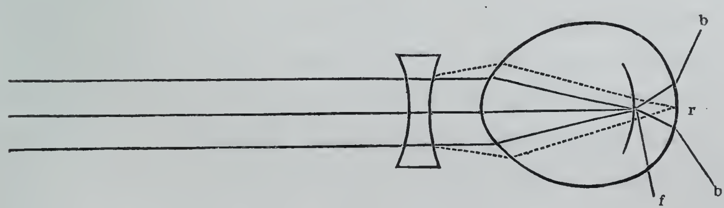
CHAPTER III.

MYOPIA.

In myopia the refracting power of the eye is increased, or the optic axis too long, so that parallel rays (emanating from distant objects), or even not sufficiently divergent rays, are brought to a focus *before* the retina; circles of dispersion are formed upon the latter, and, in consequence of this, the object does not appear sharply defined, but indistinct, and as if it were surrounded by a halo. In the short-sighted eye, therefore, only such rays as come from a finite distance, and impinge in a sufficiently divergent direction upon the eye, are united upon the retina.

Fig. 5 represents a myopic eye, in which, either on account of its being too long in the antero-posterior axis,

Fig. 5.



or its possessing too high a power of refraction, parallel

rays are brought to a focus not upon the retina (r), but before it (f) ; circles of dispersion (b b) are formed upon the retina, and the object consequently looks indistinct and blurred. In order to render the myopic eye capable of seeing distant objects (rays from which impinge in a parallel direction upon the eye), we place that concave lens before it which will give the parallel rays such a divergent direction that they are united upon the retina (r). The nearer the object the weaker must the concave lens be. If, for instance, the myopia $= \frac{1}{8}$ (the far point lying at 8″ from the eye), the patient will want about concave 10 for distance ; for objects at 2′, he will require a weaker glass (about concave 14) ; for reading at 12″, a still weaker one (about concave 26).

The range of accommodation is generally not diminished in myopia, for if we lessen the state of refraction by means of a suitable concave glass, the patient should be able to see perfectly from about 4″—5″ to an infinite distance. If this cannot be attained, the range of accommodation is diminished.

Myopic persons generally come to us with the complaint that, although they can see the very smallest objects perfectly, they cannot see well at a distance. In order to improve their vision for distant objects, they often nip their eyelids together, the reason for which is twofold : (1), they by this means narrow the opening between the lids, and thus cut off some of the peripheral rays of light, and consequently diminish the circles of dispersion on the retina ; (2), they thus exercise a certain amount of pressure upon the eyeball, the cornea becomes somewhat flatter, and the far point removed

further from the eye, the latter therefore becoming less myopic.

Myopia is often hereditary. The seeds of it are also frequently sown in childhood, either through over exertion of the eyes at near objects, or through some affection of the cornea, in consequence of which the latter may become more prominent, or be rendered cloudy. Frequently, however, short-sightedness first appears about the age of puberty. This is, perhaps, owing to the fact that many trades (*e.g.*, engraving) or professions which are apt to produce it are entered upon at this period of life. Continued working at near objects (as in watchmaking, engraving, fine needlework, &c.), is one of the most frequent causes of myopia. Persons thus employed continually accommodate for a very near point; their lens has therefore constantly to assume a more convex form, and after a time it may not be able quite to regain its original form, even when the necessity for adjusting itself for near objects has ceased. This occurs still more frequently when the lens naturally possesses but a slight degree of elasticity, for then, after it has been for some length of time accommodated for near objects, it gradually loses the power (like a bad watch-spring) of springing back to its original form, it remains too convex, even when the pressure upon its periphery ceases. In consequence of this, the focal point of the dioptric system becomes shorter, and, when the eye is in a state of rest, lies in front of the retina, and the eye has consequently become myopic. This form of acquired myopia is generally only moderate in degree.

The cause is also not unfrequently seated in the re-

fracting media. The cornea may, for instance, be more or less cloudy (from previous inflammation), or the lens may be slightly opaque; the patient then approaches the object closer to the eye, in order to obtain a larger retinal image, and in this way myopia may soon be produced.

Lengthening of the eyeball (as, for instance, in sclerotico-choroiditis posterior) is also often met with as a cause of short sight. On account of this increase in the length of the optic axis, parallel, or even not sufficiently divergent rays are brought to a focus before the retina. In extreme cases of myopia, sclerotico-choroiditis posterior is almost always present. Von Græfe, indeed, lays it down as a general rule, that when the far point lies nearer than 5″ from the eye (the myopia being therefore greater than $\frac{1}{5}$), we may almost with certainty diagnose the presence of this affection. But it may also be present in slighter cases of myopia (I have sometimes seen it in cases where the far point lay at 10″—12″ from the eye), and we should therefore invariably examine all short-sighted persons with the ophthalmoscope, for this disease is always a dangerous complication.

The diagnosis of myopia is generally not difficult. It might be confounded with weak sight (amblyopia), for we find that weak-sighted persons also hold, in order to obtain larger retinal images, small objects very near the eye; but they cannot, like the short-sighted, distinguish very small objects. Concave glasses, also, do not enable them to see them further off, indeed, they see worse through them, as they diminish the size of the retinal images too much. If we have no concave glasses at

hand, the following is a ready practical method of distinguishing between weak sight and short sight. If a person has to hold small print very near the eye, he may be suffering either from short sight or weak sight (we at present purposely pass over the consideration of the presence of hypermetropia). If he is amblyopic, and can see No. 2 at 5″, he ought to be able to see print double the size at twice the distance of the first, &c. ; for the retinal images increase in proportion to the size of the print, and all the weak-sighted require is large retinal images ; whereas in myopia it is different, for although the short-sighted eye will be able to see large print further than small, the proportion between the distance and the size of the print is far less.

Myopia and amblyopia frequently co-exist. Persons suffering from sclerotico-choroiditis posterior are generally somewhat amblyopic. Again, we have seen that original amblyopic affections, such as opacities of the lens, cornea, &c., often lead to myopia, by necessitating the close approximation of fine objects, in order to afford the eye larger retinal images. We may easily distinguish simple myopia from short sight complicated with amblyopia, by the fact that the former can be completely corrected by suitable concave glasses. A person suffering from a simple myopia should, with the proper concave lens, be able to read the same print at the same distance as the normal eye (*i.e.*, No. 18, and words of No. 16 of Jäger at a distance of 20 feet).* If,

* These test types may be obtained of the Secretary, Royal London Ophthalmic Hospital (Moorfields).

however, with the most carefully selected glasses he can only read No. 20 at that distance, he is also amblyopic. The less the concave glasses correct, the greater is the degree of the co-existing amblyopia, and *vice versâ*.

We must also be upon our guard not at once to pronounce a person myopic because he cannot see well at a distance, for we shall hereafter show that hypermetropia may also cause this imperfection, and in the latter case convex and not concave glasses are required to render vision of distant objects perfect.

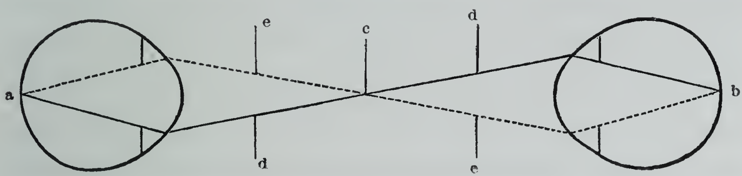
Ophthalmoscopic diagnosis of myopia.—We may also recognise myopia by means of the ophthalmoscope, which is often practically very useful. We can diagnose the existence of myopia by the following appearances :

I. If we examine the myopic eye in the erect image (merely with the ophthalmoscope without any convex lens before it) we are at once struck with the fact that we can see the fundus at some distance from the eye. If we regard one of the retinal vessels or the optic disc, and move our head to one side, we notice that the image moves in *the contrary direction ;* if we move to the right it moves to the left, and *vice versâ,* so that we get a reverse image of the fundus.

Fig. 6 will at once explain the reason of this. Let a be the short-sighted eye (myopia $= \frac{1}{6}$), and b the eye of the observer : a, being in a state of rest, is adjusted for its far point (c), which lies 6″ before the eye. The rays from the fundus of a therefore meet at c, and, crossing there, fall in a divergent direction upon the observer's eye. If the latter be myopic (accommodated for divergent rays when his eye is in a

state of rest), they will be united upon his retina (b) without the aid of any correcting lens behind the oph-

FIG. 6.



thalmoscope. If the observer's eye is normal, he will (if adjusted for his far point) require a suitable convex glass behind the mirror, in order to render the divergent rays parallel. If he, however, accommodates for a nearer point, he will also be able to unite the divergent rays upon his retina without any correcting lens.

The image of the observed eye will be seen (from this considerable distance) reversed, because, as the rays from it cross at c, the upper ray e becomes the lower ray (after they have crossed), and the lower ray d becomes the upper.

II. In examining a myopic eye in the erect image, we must place a concave lens behind the mirror, in order to obtain a distinct image of the fundus; the greater the myopia the stronger must this concave glass be, and the nearer must we ourselves approach to the eye. The field of vision will appear smaller, and the image nearer the eye of the observer than in the normal eye. The image is less bright in colour, and less illuminated, but apparently larger; for we cannot, as in the normal eye (the size of the pupil being equal) over-

look the whole optic disc at a glance, but only a portion of it.

It is of great consequence (as Donders strongly urges) accurately to determine the amount of the myopia, so that we may hereafter be able at once to judge whether it has remained stationary or has progressed. In the most favourable cases, the myopia remains stationary at the adult age; later in life it may even decrease somewhat, but generally this is not the case; and the popular idea that myopia decreases in old age is erroneous. This error is due to the fact that it was thought possible to determine the degree of myopia by the position of the near point, and partly also by the fact that short-sighted persons can see better at a distance when they get older, on account of the increasing diminution in the size of the pupil. There is nothing to be feared from a slight stationary myopia. Far different is it, however, if it be progressive; for then it is always a source of danger to the eye. Upon this important point let me give the following extract from Donders:—

"During youth, every myopia is perhaps more or less progressive; the progress of the affection is then accompanied by symptoms of irritation, which, according to Von Græfe, may even assume the character of sclerotico-choroiditis posterior. This is the critical period for the myopic eye; if the myopia does not at the same time increase to too great an extent, it may remain stationary, or at a more advanced age even decrease; if it, however, becomes greatly developed, we shall find it almost impossible hereafter to arrest its progress. At this stage we must therefore avoid

everything that may cause determination of blood to the eye, and thereby tend to increase not only the sclerotico-choroiditis, but also the tension within the eye. Among these causes we must include particularly working with the head bent forwards. I cannot lay too much stress upon this. Every progressing myopia is threatening to the eye. If it remains progressive, the eye will soon become less and less usable (troublesome symptoms at the same time showing themselves), and not unfrequently vision is irrevocably lost at the age of 50 or 60 (if not even sooner), through detachment of the retina, extravasation, or atrophy, and degeneration of the yellow spot."*

We often meet with very slight cases of myopia ; so slight, indeed, that the persons are not aware that they are at all short-sighted. If we, however, tell them to look at a distant object, a very slight concave glass of perhaps 60″ or 50″ focus improves their sight considerably. There is, however, another form of "myopia in distans," which was first described by Von Græfe, and which appears to depend upon a peculiar spasm of the ciliary muscle during the attempt of relaxation in adjusting the eye for distant objects.

MYOPIA IN DISTANS.

Von Græfe's attention was first particularly attacted to this affection by the following very interesting case :—

"A gardener (about 30 years of age), was able to read the smallest print from 4″ — 18″, medium type up

* Von Græfe's Archiv., vol. vi., 2, 220.

to 2′, the largest sized print up to $2\frac{3}{4}'$, and yet he could only distinguish the vague outline of the windows of a house fifty yards off, not even being able to recognise their division into panes; he was likewise not able to say whether or not there was any writing on a signboard at the same distance (fifty yards). A short-sighted individual, who could only read the largest print within 2′, on being placed beside him, for the sake of comparison, had a far more distinct impression of objects at the same distance, and could, without nipping his eyelids together, even distinguish the first letters (1′ in height) of the inscription on the signboard. A third myop, who could only read the largest print up to $1\frac{1}{2}'$, had yet far more distinct impressions than the first-named patient, and an excessively short-sighted individual (suffering from sclerotico-choroiditis posterior), who could only read the smallest print up to 4″, the largest up to 6″, saw distant objects about the same as the first individual, who only required concave 30 for seeing well at a distance, whereas the very short-sighted person required 3 — $3\frac{1}{2}$. The first-named patient therefore appeared to me to be a capital example of myopia in distans, and well fitted for the accurate determination of the existing conditions."

When Von Græfe tried him with an object (a portrait), gradually removing it further from the eye, there was not, as in common cases of myopia, a gradual diminution of distinctness; but at a certain tolerably constant point (considerably beyond the alleged far point) the object suddenly appeared to become wider and more indistinct, so that the patient could still distinguish the features up to about 6′, but

could not at 10′ distance even discern the outlines of the picture.

Although he could see distant objects clearly when a weak concave glass (No. 30) was placed before his eye, yet a certain time was necessary for this, and he felt that the tension of his eye changed—his description of this sensation corresponding exactly to that experienced during a change of accommodation. But if the same weak concave lens was moved rapidly past the eye, vision was not improved; and Von Græfe therefore thinks that in the latter instance the necessary changes in the refraction of the eye could not be attained in a sufficiently short space of time. If, however, whilst the patient was still looking at a distant object, a strong concave lens (No. 6) was placed before the eye, he could *instantly* see distinctly, and did not experience the above-mentioned sensation of a change of accommodation; moreover, the distant objects appeared at once perfectly distinct, even when this strong concave glass was moved rapidly past the eye.

From these facts Von Græfe thought it probable that, in looking at distant objects, the patient's eye was not accommodated for its far point, but in an opposite direction, for a much nearer, perhaps even its nearest point of distinct vision. In order to ascertain the accuracy of this supposition, he excluded one eye from participation in the act of vision by partially covering it with his hand, and then examined its position during the accommodation of the other eye.

It is a well known fact that there is no exact dependence between the convergence of the optic axes and the accommodation changes of the eye. This

may be easily illustrated by the following experiments :—

1. If we place moderately strong convex or concave glasses before normal eyes (whose power of accommodation is also good), they will see an object at a few feet distance sharply and distinctly, and there will be no alteration in the position of the optic axes, although a change in the accommodation is necessitated by the application of the convex or concave lenses.

2. If we place a prism, not too strong, with its base outwards before one eye (whilst the eyes are fixed upon an object at a few feet distance), this eye will move inwards in order to see the object sharply and singly, the convergence of the optic axes is consequently altered, whilst the accommodation remains the same. In this way the relative independence of the two functions is clearly proved; but yet this independence is only exceedingly limited. Von Græfe thinks that this apparent independence is entirely a product of the impulse for single vision, which makes itself felt when both eyes are open, and that, owing to this, the natural dependence of the two factors is to a certain degree relaxed. For as soon as the binocular act of vision is annulled, the natural dependence shows itself by the fact, that every change in the accommodation is accompanied by an alteration in the convergence of the optic axes. If, whilst a person accommodates with the one eye alternately for near and distant objects, we partially cover the other eye with our hand, so as to prevent its seeing the object (but yet permitting us to watch its position accurately), we find that, whenever the state of refraction increases (accommodation for

near objects), the covered eye always moves inwards, whereas it moves outwards when the state of refraction decreases.

Von Græfe therefore took the position of the covered eye as an index for the change in the state of the accommodation in the other eye, in order to ascertain the exact nature of myopia in distans. "For if the eye, in looking at a distant object, was not accommodated for its far point, but for a contrary direction, the other covered eye ought, when the object is gradually moved away beyond the far point, to deviate slightly inwards; and this did in reality happen, and, in fact, just at the moment when the sudden indistinctness of vision occurred. Besides this, it also appeared that, if the patient looked first at a distant object with the naked eye, and a weak concave lens (No. 30) was then placed before it, the semi-covered eye deviated slightly outwards—a proof that the state of refraction was diminished. This occurred simultaneously with the sensible change in the 'tension of his eyes' which the patient experienced. If, on the other hand, strong concave glasses (6) were held before the eye, in which case distinct vision instantaneously occurred, not the slightest deviation in the position of the other eye appeared, from which I concluded that now, also, no alteration in the condition of accommodation of the eye had occurred, and that consequently the eye was previously, in looking at distant objects, in almost its maximum state of refraction, or, at all events, more adjusted for its near than for its far point.

"It would therefore appear that, in myopia in

distans, the comparatively small circles of dispersion which distant objects would produce as long as adaptation for the far point was preserved, are in some way incompatible with the act of vision, so that under their influence an impulse for the induction of an opposite condition of accommodation arises."*

Persons suffering from this peculiar form of myopia in distans are enabled to see most accurately at a distance with very weak concave glasses. Their far point is at a normal distance from the eye, their vision is perfectly good, only when accommodating for their far point a sudden spasmodic increase in the refraction of their eye occurs, and the object appears dim and indistinct.

This affection is undoubtedly very rare. Donders thinks that myopia in distans is often due to abnormal dilatation of the pupil. When speaking of spasm of the ciliary muscle, I shall hereafter show that there may be apparent myopia in distans, the patient seeing better at a distance with a slightly concave lens, and yet his eye be hypermetropic, and not myopic; for upon the instillation of a strong solution of atropine, and consequent paralysis of the ciliary muscle, he requires convex, and not concave glasses for distant vision.

The degree of myopia is easily determined according to Donders' method. If, for instance, a myopic person can read No. 1 of Jäger up to a distance of 10″, his far point lies at 10″, and his myopia $= \frac{1}{10}$; for with a concave glass of 10″ focus he would be able to

* Archiv., ii., 1, 167.

unite parallel rays upon the retina; for does not this glass render parallel rays so divergent as if they came from a distance of 10″ before the eye? We at the same time obtain a clue as to what glasses the patient will require for distant objects.

But although theoretically a concave glass of 10″ focus should be the proper one, we find in practice that it would be too strong. This is due to the convergence of the optic axes, for this convergence prevents the eye from accommodating itself for its far point, the latter is only attainable when we look at distant objects with parallel optic axes. We should therefore find that our patient would perhaps require concave glasses of 12″ or 13″ focus.

Nothing is easier than to determine whether or not the glass thus found accurately suits the patient's sight. We have but to let him look through the proper concave glass at No. 20 of Jäger's test-type, placed at a distance of about 20′, so that the rays would impinge in a parallel direction upon the eye. In our supposed case, the spectacles would be No. 10 concave. With these he can read Nos. 19 and 20 fluently. We now alternately place very weak concave or convex glasses before the spectacles, and try their effect. If slightly concave glasses improve vision, the original glasses (No. 10) are too weak; if, on the other hand, convex glasses improve it, they are too strong. If neither the one nor the other render any improvement, the spectacles suit exactly. Let us illustrate this by a few simple examples:—

A comes to us with a myopia $= \frac{1}{10}$, we give him

concave glasses of 10″ focus,* and tell him to read No. 20 at 20′ distance. He can do so, and even see No. 19, but somewhat indistinctly. We place No. 60 convex before the spectacles, and find that this renders the letters clearer, convex 50 improves vision still more (with it he can read No. 18), but convex 40 renders it more indistinct. The original glass (concave 10) is, consequently, somewhat too strong, and, in order to suit the patient's sight exactly, we must deduct 50 from it. His myopia is, therefore, $\frac{1}{10}-\frac{1}{50}$; consequently, $=\frac{1}{12\frac{1}{2}}$ We give the patient concave 13, and find that neither concave or convex glasses render any improvement. He is therefore accurately suited.†

B also appears to have a myopia $=\frac{1}{10}$. He is tried in the same way with concave 10. In his case we, however, find that convex glasses render his vision more indistinct, but that concave glasses improve it—concave 50 most of all—we therefore have to add this to the original glass (No. 10), which was too weak. His myopia therefore $=\frac{1}{10}+\frac{1}{50}=8\frac{1}{3}$. We try concave 9, and find that vision is not improved by any weak convex or concave glass.

Another patient desires to have spectacles which will enable him to see objects at a distance of 2′ (for

* In Germany, and at the Royal London Ophthalmic Hospital, Moorfields, the concave glasses are numbered according to their focal length (which is negative).

† The distance between the glass and the eye (about half an inch) we have not calculated, in order to render the formula as simple as possible.

instance, the music whilst playing the piano). For distant objects he requires concave 12. How are we to find the right glasses for objects at 2′? Simply thus: If his myopia equals about $\frac{1}{12}$, the glasses to see with at 24″ will be about $-\frac{1}{12}+\frac{1}{24}=-\frac{1}{24}$. Hence concave 24 will suit him for seeing at 2′.

In the same way we can find what glasses are required for reading at 1′ distance in a myopia $=\frac{1}{6}$; $-\frac{1}{6}+\frac{1}{12}=-\frac{1}{12}$. Concave 12 would be required for this purpose. We shall, however, find that the patient requires a somewhat weaker glass, because the convergence of the optic axes to a point 12″ distant already necessitates an accommodation for a nearer point.

As the amount of the range of accommodation (A) which the patient possesses very materially influences our choice of spectacles, and the question whether or not they are to be used for near objects, we must, in the next place, shortly consider how the range of accommodation is to be tested in a myopic eye. We may do this in two ways:—

1. We let the patient read No. 1 of the test type, and, by alternately moving it nearer and further from the eye, we ascertain his near (p) and far (r) point. Let us suppose that p = 3″, and r = 6″. His range of accommodation is found by the formula—

$$A=\frac{1}{p}-\frac{1}{r},\ \text{therefore } A=\frac{1}{3}-\frac{1}{6}=\frac{1}{6}$$

2. Donders has lately, however, preferred the following plan:—He gives the patient those glasses which

neutralize the myopia, and enable him to see distant objects distinctly (by means of which he can therefore unite parallel rays upon the retina). Let us again suppose that No. 10 (concave) is the weakest glass with which he can read No. 19 or 18 quite distinctly and sharply at 20′ distance. His far point will therefore, with concave 10, lie at infinite distance (∞). With the same glass we now try how near he can read No. 1 comfortably and with ease ; let us suppose that this be at 5″, his A therefore $=\frac{1}{5}$, for $r = \infty$, $p=5$, $A=\frac{1}{5}-\frac{1}{\infty}=\frac{1}{5}$

The great advantage of this method is, that the patient really accommodates for his far point, which is not the case in the former plan ; for owing to the amount of convergence at 6″, the patient cannot relax his accommodation sufficiently to accommodate for his far point.*

Short-sighted persons often inquire whether they may wear spectacles. Now, all practitioners are, I think, agreed as to the advisability of allowing myopic persons spectacles, for the purpose of seeing distant objects. For we thus change their eyes into normal ones, and enable them to unite parallel rays upon the retina. We should, however, prescribe the weakest glass with which the patient can see clearly and distinctly at a distance, so that he may only make use of a minimum of his power of accommodation, and not have to strain it unduly when observing near objects. For we must remember that he will but seldom have to look for any length of time at a distance, but will alternately

* We have already (p. 21) explained the method of testing the range of accommodation with a strong convex lens.

observe near and distant objects. One moment looking at something on the opposite side of the street, the next into a shop window, or at some object near at hand. Now, if the glasses are too strong, he is already obliged to use more than a minimum of his power of accommodation when observing distant objects, and will consequently have to make use of a still greater amount (perhaps almost the whole) when looking at things but a short distance from him. His myopia will therefore soon increase.

There can also be no harm in allowing short-sighted persons glasses for the purpose of seeing things at a few feet distance (*e.g.*, playing the piano, &c.)

The patient may, however, also desire spectacles for reading, writing, &c. Now, Donders thinks that although it is advisable to give myopic persons at first weaker glasses for reading than for distant objects, we should at a later period, if their range of accommodation be good, give them (even for reading) spectacles which completely neutralize their myopia.

It is still, however, a much debated question whether short-sighted persons should be allowed glasses for reading, writing, &c. Donders strongly recommends it (except in exceptional cases) for the following reasons:—

1. Because strong convergence of the optic axes is necessarily paired with tension of the accommodation. The latter is an associated action, not arising from the mechanism of the convergence, but existing within the eye itself, and may consequently easily lead to an increase of the myopia. Besides this, the pressure of the muscles upon the eyeball appears to be greater when the optic axes are convergent than when they are

parallel, and this increase of pressure cannot but tend to give rise to the development of posterior staphyloma.

2. On account of the habit which short-sighted persons have of bending their head forwards during reading or writing. This must cause an increased flow of blood to the eye and an increased tension within the eye itself. Owing to this the development of sclerotico-choroiditis posterior, effusions of blood, and detachment of the retina, which are so apt to occur in short-sighted persons, are undoubtedly greatly promoted. For this reason we should always tell these patients to read with their head well thrown back, and to write at a sloping desk.

But it may, on the other hand, be urged that it is just in looking at near objects that myopic persons have an advantage, for they can see them remarkably distinctly. And the great danger is, that after reading for a short time with spectacles, the patient on getting somewhat fatigued will, instead of laying the book aside, approach it nearer to the eye, in order to gain greater retinal images, and thus strain and tax his power of accommodation too much. If we, for instance, give a patient, whose far point lies at 8″, a pair of spectacles which enable him to read at 12″, he will, if not very careful, after a short time almost insensibly bring the book nearer to his eyes, and thus have to make use of a greater amount of accommodation. If he does this frequently, he will soon increase his myopia. The greater the range of accommodation the less harm will spectacles do, and *vice versâ.*

Spectacles may also be used for near objects in those cases of myopia in which asthenopia (depending upon insufficiency of the internal recti muscles) shows

itself as soon as the patient has read or worked at near objects for a short time.

Whilst these forms of myopia may be furnished with spectacles for near objects, it is very dangerous to permit their use in patients whose range of accommodation is very limited, and who, moreover, suffer perhaps from such an amount of amblyopia (generally depending upon sclerotico-choroiditis posterior) that they cannot read No. 4 or 5 of Jäger even with the most accurately chosen glasses. Such patients will bring the object very close to the eye, in order to obtain large retinal images, the accommodation will be greatly strained, the intra-ocular tension be increased, and great mischief will be sure to ensue. If there is much amblyopia, spectacles should not be permitted at all for near objects.

CHAPTER IV.

INSUFFICIENCY OF THE RECTI INTERNI MUSCLES.

Let us suppose (in order to illustrate this affection) that a short-sighted person (whose myopia = $\frac{1}{8}$) comes to us with the complaint that after he has been reading for a short time (without glasses), the letters become confused and blurred, and appear to run into each other; pain in the eye and around the orbit is at the same time experienced, and if he persists in reading the eyes get red and water; so that he has at length to lay the book aside. After resting his eyes for a few minutes he can resume his reading, to be, however, shortly interrupted again by the same train of symptoms. Upon examination we find that his eye looks normal, his sight is capital (he is able to read the very finest print), and his range of accommodation good. He is, however, myopic (his far point lying at 8″ from the eye); he will consequently, if he reads without spectacles, have to hold the print nearer than this (about 6″). If we now tell him to look at our uplifted forefinger, and approach this gradually to the eye, we find that when it gets to about 6″ distance one eye becomes a little unsteady in its fixation, and then gradually, or else suddenly and spasmodically, deviates

outwards. The same deviation occurs when we cover one eye so as to exclude it from participation in the act of vision, even perhaps if the object be some feet distant. Now, this deviation shows that the internal recti are not sufficiently strong to keep up the necessary amount of convergence (for 5″—6″) during reading. As soon as we exclude one eye (by covering it) from the act of vision, it follows its natural impulse, and deviates outwards, thus showing the weakness of its internal rectus; in order to avoid diplopia, this tendency to deviation is, however, suppressed by the patient when he looks at an object (if it be not brought too near). After a time, if he continues to work much at near objects, one eye moves outwards, and a permanent divergent squint is produced, the patient suppressing the image of the squinting eye in order to avoid diplopia; but this active negation of the pseudo-image soon leads to greater or less weakness of sight of the squinting eye. Other patients avoid the disagreeable symptoms of asthenopia by closing one eye whilst reading, &c.

We can in such cases easily, by means of prisms, satisfy ourselves of the diminished strength of the inter- recti muscles, and the increased power of the external recti. Before explaining this, it will be well to describe the different kinds of diplopia we meet with, and also to say a few words as to the action of prisms, as some of my readers may not be quite conversant with these subjects.

In explanation of diplopia, I give the following extract from my papers on Paralytic Affections of the Muscles of the Eye, Ophth. Hosp. Reports, Nos. 8, 12:—

"An object only appears single when both optic

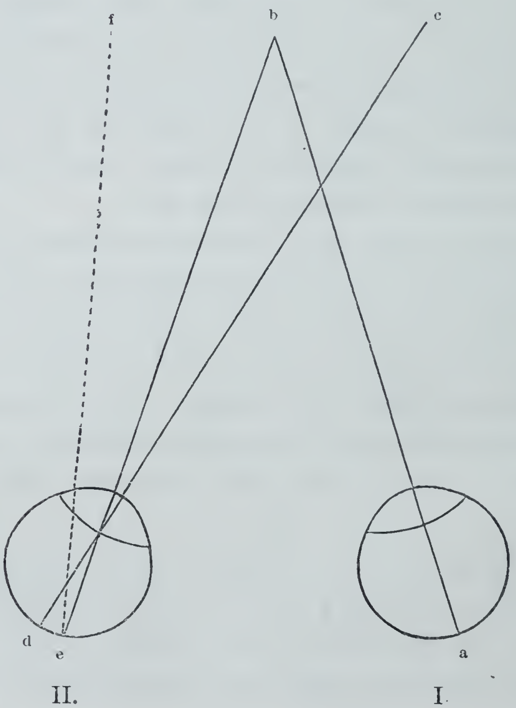
axes are fixed upon it; any pathological deviation of either optic axis must necessarily cause diplopia, as the rays from the object do not then fall upon identical portions of the retina. The slightest degree of diplopia is that in which the double images are not yet distinctly defined (are masked), but seem to lie slightly over each other, so that the object appears to have a halo round it.

"We meet with two kinds of double images.

"1. *Homonymous* (or *direct*) diplopia, in which the image to the right of the patient belongs to his right eye, the left image to the left eye.

"2. *Crossed* double images, in which case the image

Fig. 7.



to the right of the patient belongs to his left eye, that on his left to his right eye.

"Homonymous diplopia is always produced (except in incongruence of the retinæ) in convergent squint, for if the eye deviates inwards from the object, the rays coming from the latter will fall upon the inner portion of the retina, and the image will (in accordance with the laws of projection) be projected outwards as in Fig. 7.

"Let I. be the right eye, whose optic axis is fixed upon the object (b). II. The left eye, whose optic axis (c d) deviates inwards from the object, the rays from b therefore fall upon e, a portion of the retina internal to the macula lutea (d), and the image is consequently projected outwards to f; b and f are therefore homonymous double images, the image b, which is to the right of the patient, belonging to his right eye, the image f to his left eye.

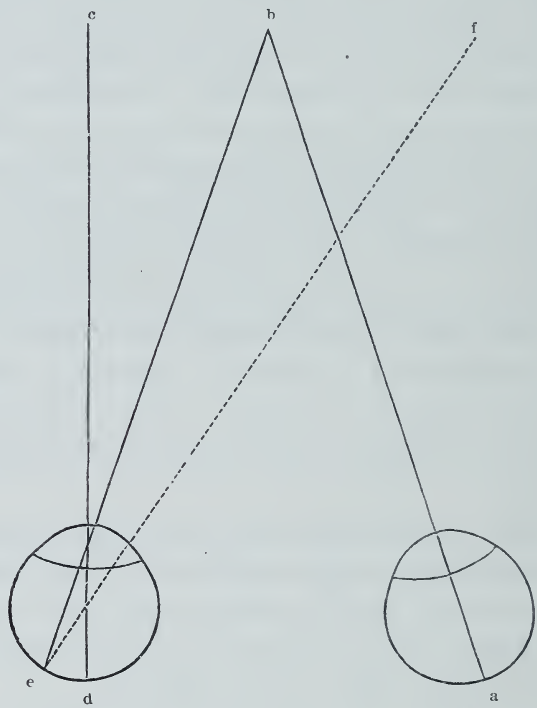
"Crossed double images arise in divergent squint, for the one eye deviating outwards from the object, the rays from the latter fall upon a portion of the retina external to the macula lutea, the image is projected inwards, and crosses that of the other eye, as in Fig. 8.

"I. The right eye, whose optic axis is fixed upon the object (b). II. The left eye, whose optic axis (c d) deviates outwards from the object, the rays from the latter therefore fall upon e, a portion of the retina external to the macula lutea (d), and the image is projected to f, crossing the image b; the image f, which would lie on the patient's right hand, would therefore belong to his left eye, the image b, which would lie on his left side, to the right eye."

"If one eye squints upwards, the rays will fall upon

the upper portion of the retina, and the image be projected *beneath* that of the healthy eye. The reverse will be the case if the eye squints downwards, for then

Fig. 8.



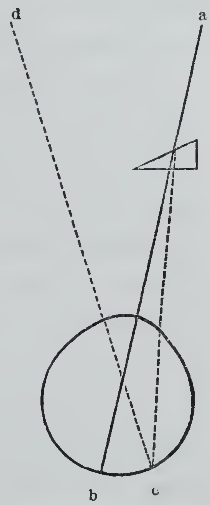
the rays fall upon the lower portion of the retina, and the image will be projected *above* that of the healthy eye."

"We should never forget to ascertain whether the diplopia be monocular or binocular; if it be the latter, it will of course disappear upon the closure of the healthy eye." *—Ophthalmic Hospital Reports, No. 9, p. 139.

* "In examining the double images of a patient it is convenient to place a slip of red glass before the sound eye, for we thus enable him readily to distinguish the two images by their colour, and we also weaken the intensity of the image of the sound eye,

Let us now glance at the action of prisms. When a ray of light falls upon a prism, it is refracted towards its base. If, for instance, whilst we look at an object (*e.g.* a lighted candle) at 8′ distance with both eyes, a prism, with its base towards the nose, is placed before the left eye, the rays from the candle will be deflected towards the base of the prism, and fall upon a portion of the retina internal to the yellow spot, and be consequently projected outwards, giving rise to homonymous diplopia. As we are, however, very susceptible of double images, the eye will endeavour to unite them by an outward movement (its external rectus becoming contracted), which will again bring the rays upon the yellow spot, but at the same time of course cause a divergent squint. Fig. 9 will explain this.

Fig. 9.



Let a b be the optic axis of the left eye fixed (with the other) upon a candle 8′ off. Now, if a prism (with its base towards the nose) be placed before it, the rays are refracted towards the base of the prism and do not, as in the other eye, fall upon the yellow spot, but on a portion of the retina (c) internal to the latter, and the image is projected outwards to d; homonymous diplopia therefore arises, and to avoid this the

and approximate it more to that of the affected one, whose image, owing to the rays from the object falling upon an excentric portion of the retina, will be less intense in proportion to the distance of the spot upon which the rays fall from the macula lutea."—*Ibid.*

external rectus muscle contracts and moves the eye outwards, so as to bring the macula lutea (b) to that spot (c) to which the rays are deflected by the prism. As the rays from the object will now fall in both eyes upon the macula lutea, single vision will result, accompanied, of course, by a divergent squint of the left.

The reverse will occur if we turn the prism with its base to the temple, for then the rays will be deflected to a portion of the retina to the outer side of the macula lutea, and the image will be projected inwards across that of the right eye, and crossed diplopia will be the result. In order to remedy this, the internal rectus will contract and move the eye inwards, so as to bring the macula lutea to that spot to which the rays are deflected by the prism. There will consequently be a convergent squint.

As the internal recti muscles are far more constantly used than the external, they gain a greater degree of strength than the latter, and can overcome far stronger prisms by a voluntary inward squint. In a normal eye the internal rectus can generally overcome a prism of 14°, whereas the external rectus cannot often overcome one stronger than 5°—6°.

In prismatic glasses we have therefore the best test for the relative strength of the muscles. Now, in insufficiency of the internal recti we find the strength of these muscles greatly diminished, so that they can only perhaps overcome a prism of 4°—5° instead of, as in the normal eye, one of 14°—16°. The external recti in such cases gain unusual strength, on account of the diminished force of their opponents, being now able to overcome prisms of perhaps 12°, 14°, 16°.

Cases of insufficiency of the internal recti may be treated in different ways, according to whether our purpose is merely to alleviate, or to cure the affection. We may alleviate it in two ways: 1. By the use of concave glasses for reading, &c. For if we give the patient (suffering from myopia $\frac{1}{6}$) a pair of spectacles which enable him to read at a distance of 12″—14″, the amount of convergence of the optic axes (and consequent action of the internal recti muscles) will be proportionately decreased, and he will now be able to read with ease and comfort. But the spectacles act only as a palliative, and the internal muscles become indeed weaker instead of stronger, for they will now have less than their accustomed share of work. Besides, there is the already mentioned danger, in using spectacles for reading, &c., that the patients are apt after a time, when their eyes get somewhat fatigued, to approach the object too near the eye, and thus strain their power of accommodation.

2. The asthenopia may be alleviated by the use of prisms with the base *turned inwards.* For suppose that the natural tendency of the eye is to deviate outwards (in reading, &c.) about $\frac{1}{2}'''$, and we place a prism, with its base inwards, of sufficient strength to neutralize this outward deviation exactly (by bringing back the retinal image to the macula lutea from the spot where it would fall if the eye deviated outwards), we should enable the person to read with comfort; for by means of a prism thus applied he would see single even when his eye deviated outwards to the extent of $\frac{1}{2}'''$.

It is better, however, in all cases to cure the affection; and this may be done either by strengthening the internal recti muscles through constant exercises

with prisms, or through weakening their opponents (external recti) by a tenotomy of the latter. Let us briefly consider the relative advantages of these two modes of treatment.

1. *Prismatic glasses.** These must be very weak at first, and are to be applied with their base outwards before one eye, so that the rays of light (from a candle at 8′ distance), will impinge upon a portion of the retina slightly to the outer side of the macula lutea ; to avoid the diplopia arising from this, the eye will move inwards, in order once more to bring the rays upon the yellow spot. By gradually increasing the strength of the prism, we exercise the internal rectus more and more, and it will soon acquire greater strength.

This plan, however, requires very great patience and accuracy both on the part of the medical man and of the patient, and the latter generally soon gets wearied of these exercises, which, in order to ensure anything like success, would have to be continued for a length of time. It is therefore far better to have recourse to an operative proceeding.

2. *Tenotomy of the external rectus* muscle. Our object in performing this operation in such cases is to strengthen the abnormally weak internal rectus by a division of its opponent, so that the former will have a less resistance to overcome. Our primary object must be to enable the patient to read, write, &c., without any difficulty, and we must of course be chiefly guided in

* The short-sighted eyes must be furnished during these exercises with concave spectacles, so as to be able to see the object distinctly.

this by the state of his sight. If he suffers from a myopia $= \frac{1}{7}$, he will require to read at about $5\frac{1}{2}''$, and to be able to converge his optic axes steadily and for some time upon an object at about $4\frac{1}{2}''$. We must, above all things, endeavour to obtain this result, and it will not matter much if there should be after the operation a slight convergent squint ($\frac{1}{2}''' — 1'''$) when he is looking at distant objects; for in order to escape the diplopia consequent upon this, the external rectus will contract, and by moving the eye slightly outwards remedy the squint, and once more re-adjust both optic axes upon the object. Of course the amount of convergence (for distance) which we may permit with safety depends entirely upon the relative strength of the internal and external rectus. Supposing that in a myopia $= \frac{1}{7}$, the internal rectus could, before the operation, only overcome a prism of $4° — 5°$, but that the external rectus could overcome one of $14° — 16°$, it would be perfectly safe to permit a convergence of $\frac{1}{2}''' — 1'''$ for distance, more particularly if the excluded eye had, before the operation, deviated outwards $\frac{3}{4}''' — 1'''$ when covered. In such a case, even after its division, the external rectus would remain sufficiently strong to rectify the convergent squint.

The following considerations must guide us as to the extent of the tenotomy :—

1. The amount of the myopia and the consequent distance for which the optic axes must converge in reading, &c.

2. The strength of the prisms which can be overcome by the internal and external rectus.

3. The degree of its deviation outwards (in looking

at distant objects) which occurs when the affected eye is covered.

4. The mode of deviation when the object is approximated to the eye. Von Græfe thinks that a considerable correction is indicated if the eye moves suddenly spasmodically outwards, at the moment when the insufficiency of the internal recti shows itself, whereas we must be more guarded in the extent of our operation, if, as the object is gradually brought nearer the eye, the one eye moves outwards in about the same ratio as the other moves inwards, thus assuming an associated, in place of an accommodative, movement. Still more cautious must we be if the affected eye remains stationary at a certain point, without apparently deviating any further outwards.

If both internal recti are very much weaker than normally, and either eye, when excluded, deviates outwards $\frac{1}{2}''' — 1'''$, it may be necessary to divide both abductors. But this should never be done at one operation. We should divide one external rectus, and then after a few days, when the final result of this operation is apparent, we must very carefully and accurately examine the other eye, in order to see to what extent the affection still remains, and to what extent an operation is indicated. The safer plan is, at the second operation, to divide the other abductor only partially, in order not to leave too much convergence for distance, or else to divide it completely, but in a most careful manner, and then to test the accommodative movements of the eyes, and the amount of convergence for distance, and if the latter is at all excessive, to insert a conjunctival suture.

I do not think that the sub-conjunctival method of operating for squint is indicated in these cases of partial or very careful tenotomy, because we cannot in this way perform a partial tenotomy efficiently, as we cannot see how much of the tendon we have left standing. Again, in the sub-conjunctival operation we cannot, if necessary, diminish the effect by a conjunctival suture. Indeed, I in all cases prefer Von Græfe's operation,* although the sub-conjunctival is advantageous when one cannot obtain sufficient assistance.

* I would refer my readers to Von Græfe's admirable articles upon strabismus, upon which the above remarks upon the symptoms and treatment of insufficiency of the internal recti muscles are chiefly based.—*Vide* his Archiv., vol. iii. 1.

CHAPTER V.

SCLEROTICO-CHOROIDITIS POSTERIOR.

THERE is, perhaps, no disease of the eye which requires greater tact and management, greater "nursing," corporeally and mentally, than progressing sclerotico-choroiditis posterior. If we thoroughly understand the symptoms of the disease, and the proper course of treatment to be pursued from the outset, if we are aware of the grave complications which may arise if it be carelessly or ignorantly treated, we may preserve many eyes in comparative usefulness and comfort which would otherwise be soon destroyed. Let us therefore consider the symptoms, diagnosis, prognosis, and treatment of this important disease.

It was first accurately described by Von Græfe, who gave it the above name, and in my description of it I shall chiefly follow his views.

Symptoms. The eyeball often appears larger, more prominent, and of an ovoid shape, the eyelids being more widely apart, which is particularly noticeable when only one eye is affected. The shape of the eyeball is changed, it appears lengthened in its antero-posterior diameter, it is more oval and the infundibulum or hollow which appears in the normal eye between the

outer canthus and the globe (when the eye is much turned inwards), has disappeared, so that the posterior segment of the eyeball looks lengthened and square, showing often also a bluish tint. If the disease is considerable, the lateral movements of the eyes are often somewhat curtailed. The patients complain frequently of a sensation of tension and fullness in the eye, as if, as they often express it, the latter was too large for the socket; they also at times experience more or less circum-orbital and intra-ocular pain.

We can, however, only diagnose the disease with certainty by means of the ophthalmoscope, for a considerable posterior elongation of the eyeball (staphyloma posticum) may exist without any appearance of sclerotico-choroiditis posterior.

The ophthalmoscopic appearances are generally most marked and unmistakeable. The characteristic symptom is a brilliant white crescent at the edge of the optic nerve entrance, generally at the outer side (with the reverse image it would of course appear towards the nasal side of the patient). This crescent varies much in size, from a small white arc to a large zone, extending, perhaps, all round the optic nerve, and embracing even the region of the macula lutea; its greatest extent is always in the direction of the latter.* Its edges may

* We must, however, be careful not to call every little white rim at the edge of the entrance sclerotico-choroiditis posterior, for this may be caused simply by the choroid receding somewhat from the entrance, and permitting the light to fall at this spot through the retina upon the denuded sclerotic, and thus affording the appearance of a white, glistening rim. But this arc is very narrow, and there are no appearances of atrophy of the choroid, irregular patches of pigment, &c., at its edges.

be either sharply and distinctly defined, or may be irregular, and gradually lost in the surrounding healthy structures; irregular patches of pigment are strewn about its margin, and also, perhaps, on its surface, so that little dark islets of varying size and form appear in its expanse. The crescent itself is of a brilliant white, so much so, indeed, that the entrance, by contrast, appears to be abnormally pink. The small retinal vessels can, on account of the white background, be traced more distinctly, and their minute branches more easily followed over this patch than in the neighbouring fundus. This white crescent is due to a thinning or atrophy of the stroma of the choroid (indeed, the latter has occasionally been found quite wanting in this situation); the pigment cells are not necessarily destroyed, but there is an absence of the pigment molecules, for those irregular black patches mentioned above are pathological agglomerations of pigment. On account of the loss of pigment, and the atrophy or thinning of the stroma of the choroid, the glistening sclerotic shines through the latter, and lends the brilliant white appearance to the figure. Another effect of this want of pigment is the glaring which the patient experiences in a bright light. The amblyopia which almost always exists in this disease is also, undoubtedly, partly due to this fact, for we find that such patients are remarkably benefited by blue spectacles. Much of the amblyopia is, however, most likely owing to the disturbance in the intra-ocular circulation, produced by the state of chronic congestion of the venous system of the eye, for we find that vision is generally greatly improved by depletion, and more especially by artifical leeches.

The retina does not generally suffer from this loss of pigment in the choroid, except that a slight diminution in the distinctness of perception is produced. The "blind spot" (answering to the optic entrance) is somewhat enlarged, but this increase does not correspond at all to the size of the crescent, and vision is only impaired, not destroyed, in this extra portion of the blind spot.

The disease may remain stationary or progress. If the former is the case, the myopia does not increase, the circum-orbital and intra-ocular pains diminish or cease, and with the ophthalmoscope we find that there is no increase in the size of the crescent, and that, perhaps, a regular deposit of pigment again takes place.

Far different is it if the disease progresses. The myopia is then found to increase more or less rapidly, vision becomes dimmed or greatly impaired, the patients are often continually haunted by "blacks" floating before their eyes, which may assume all kinds of fantastic shapes, and are due to opacities in the vitreous humour. At other times they are greatly disturbed by showers of bright stars and flashes of light, and they become more and more dazzled by the light on account of the increased atrophy of the choroid and loss of the pigment. But the progress of the affection is best watched with the ophthalmoscope. The edges of the crescent become irregular and ill-defined, small white patches show themselves around it (symptomatic of the progressive atrophy of the choroid), and these, gradually increasing in size, coalesce with each other and with the original crescent, so that the latter may in time extend completely round the entrance, which thus becomes

embedded in a more or less broad, white, glistening ring, which extends chiefly in the direction of the yellow spot. In such cases a superficial observer might suppose that the optic entrance was greatly enlarged, or even that the optic nerve (from the white appearance) was atrophied, but on closer examination the distinction between the entrance and the white zone is easy, for the disc of the optic nerve looks abnormally pink, on account of the contrast with the bright white of the surrounding ring, and its vessels are more easily traceable over the latter than in the disc.

A similar process may also occur in the region of the macula lutea. Little white patches appear, which increase in size, and coalesce, giving the whole an appearance of alternate white and dark reticulated spaces, the white spots being due to the sclerotic shining through the atrophied stroma and pigment layer of the choroid. Von Græfe thinks that the retina may in this situation participate more rapidly in the disease than otherwise, on account of its being thinner at this spot. If the atrophy of the choroid in the region of the macula lutea, and that around the optic entrance, progress, the two separate processes may gradually extend towards each other (leaving less and less healthy structure between them), until they finally pass into each other and form one vast white figure.

The occurrence of the disease at the macula lutea causes generally great impairment of vision, and the patients then also complain of the constant appearance of one or more central fixed black spots (scotomata).

Von Græfe has also noticed the important fact that the amaurosis in sclerotico-choroiditis posterior may be

due to a cupping of the optic nerve through increased intra-ocular pressure. This is thus produced :—When the sclerotic becomes thickened with advancing age it loses some of its elasticity, and cannot, as heretofore, yield to the increased intra-ocular pressure and bulge backwards, the optic nerve entrance, being the next least resisting part, will consequently yield before the pressure, and become cupped. If this occurs, the tension of the eyeball increases, the pupil becomes larger and more sluggish, the cornea somewhat anæsthetic, the field of vision contracted (either concentrically or laterally), and vision is often totally destroyed. In such cases the only remedy is an early iridectomy.

Complications.—*Vitreous opacities.* The vitreous humour almost always undergoes some changes in sclerotico-choroiditis posterior ; indeed, Von Græfe thinks that two-thirds of the affections of the vitreous are due to this disease. Although it becomes fluid generally only at its posterior portion close to the retina, the synchysis may, though rarely, extend to the whole of the vitreous.

We should always regard opacities in the vitreous with anxiety if they are numerous or very diffuse, and if the myopia is progressive. The opacities may be of various kinds. The patient perhaps at first only notices a dark speck, which he cannot wipe away ; afterwards thin flaky membranes may appear, which float about before the eye, assuming different forms and positions with its every movement. These opacities generally throw a shadow upon the retina, the more so in proportion to their proximity to the latter ; if they lie further off they may not throw individual shadows,

but only cause a general dimness of vision. With the ophthalmoscope we can readily distinguish them as dark, fixed, or floating bodies of various size and shape. Sometimes, however, they are so delicate and fine that we cannot individualize them, the whole fundus only appearing more or less hazy and indistinct.

A more dangerous form of opacity is that in which the vitreous becomes suddenly and diffusely clouded, so that we cannot thoroughly illuminate any portion of the retina with the ophthalmoscope; the whole looks clouded and indistinct. These sudden attacks of haziness may recur several times; and then, when the dimness at length disappears, and we can again examine the fundus with the ophthalmoscope, we but too often find that the retina has become detached!

Pigmentation of the retina. As the sclerotico-choroiditis posterior progresses the retina may become infiltrated with pigment from the choroid, and thus a considerable impairment of vision may result.

Detachment of the retina. This is but a too frequent complication, and occurs chiefly in two ways.

1. The retina not following the traction of the choroid and sclerotic (which bulge posteriorly), a serous, or hæmorrhagic effusion may occur between the retina and choroid, and the former be partially or entirely detached. The detachment generally occurs at the lower portion of the retina, owing to the gravitation of the fluid; it may, however, be at first slightly detached at the upper or any other part; but in the course of a few days or weeks we invariably find that the detachment has extended to the lower portion. Our attention should be particularly directed to this

complication if we find that the upper or lower half of the field of vision has become indistinct, or if the patient complains of a cloud, like the "peak of a cap" hanging before his eyes, and if he sees objects broken or notched.

The effusion may, however, burst through the retina into the vitreous without detaching the former.

2. Heinrich Müller has pointed out* that detachment of the retina may not only occur through the pressure of fluid from behind, but also through traction from before. The latter is thus produced :—when the exudations in the vitreous humour shrivel up and contract, they, being also attached to the retina, draw the latter forward and detach it from the choroid.

Opacity at the posterior pole of the lens sometimes occurs in the later stages of sclerotico-choroiditis posterior: this opacity, as it is situated generally very close to the "turning-point" of the eye, retains its position in whichever direction the eye is moved. Cataracta accreta and atrophy of the globe may close the scene.

Causes. Although there is sometimes a predisposition (perhaps hereditary) to this affection in the congenital formation of the eyeball, the principal cause is generally the state of congestion of the eye produced during accommodation for near objects. During such accommodation a certain pressure upon the eye and increased intra-ocular tension always occurs, the venous circulation within the eye becomes retarded, and a more or less considerable state of mechanical congestion is produced. We find instances of this in those cases

* Von Græfe's Archiv. iv. 1, 372.

of amblyopia due to opacities of the cornea, lens, &c., in which a myopia is acquired through the necessity of bringing small objects very near the eye, in order to gain larger retinal images; a similar thing occurring also if the patient, whilst using spectacles for reading, &c., gradually approaches the book too near his eyes. We occasionally find that vitreous opacities, and even detachment of the retina, occur in such cases soon after continued reading and working with spectacles. Von Græfe considers that the disease is most likely due to a chronic inflammatory process of the sclerotic and choroid, and has therefore designated it "Sclerotico-choroiditis posterior." He says, "In opposition to this view it might certainly be objected that in reality inflammatory products are wanting in both tunics, but the considerable hyperæmia of the choroid itself, the changes in its pigment, the obliteration of the ciliary vessels, and the atrophy in the posterior portion of the tunic, the deranged nutrition of the vitreous humour, the frequent combination with hæmorrhagic processes, and, finally, the beneficial action of antiphlogistics, all these furnish reasons why the affection should not be regarded only as the result of a simple passive distension, but as a state of chronic inflammation."*

I am well aware that this opinion has been strongly opposed by some recent eminent writers, I cannot say, however, that they have been, at present, at all successful in demonstrating the correctness of their views. There is no doubt that a "crescent" (I purposely drop the title sclerotico-choroiditis posterior for the present,)

* Von Græfe's Archiv. i., 1, 399.

may exist for years without any increase in size, or without any choroidal changes in its vicinity, its margin may be distinctly and sharply defined, and yet this may gradually become irregular and break down until the crescent becomes larger and larger ; and the disease in this case evidently extends from the periphery in a centrifugal direction. Such being the case, I do not think that it is correct to call a well-defined, sharply circumscribed crescent congenital and *non-inflammatory*, and maintain that any increase in size which may hereafter occur is never due to an enlargement of the crescent itself, but to *inflammatory* changes in the choroid, either in the close vicinity of the crescent, or in the region of the yellow spot, and that through the gradual extension and amalgamation of these independent processes, which finally coalesce with the original crescent, it may become impossible to distinguish the latter from the secondary inflammatory changes in the choroid. Now, as the changes resulting from this secondary inflammatory process, often produce appearances so exactly similar to those of the original crescent that even the best observers cannot distinguish where the one ends and the other commences, or, indeed, see any difference between them, why may we not assume that the crescent is also of inflammatory origin ? Do we not often see that those changes, which are conceded to be inflammatory when occurring at the yellow spot and in the vicinity of the crescent, frequently commence at the well-defined margin of the latter, rendering it irregular, and gradually increasing its size ? Some go so far as to diagnose a crescent to be congenital and non-inflammatory (in a patient of advanced years whom they

have never seen before), chiefly because its edges are regular and well-defined. I do not of course deny that crescents are sometimes congenital, but does this fact even prove that they are non-inflammatory? At all events, I think it is far safer for the patient that we should consider the myopic eye as more or less diseased, and that we should look upon even a slight and regularly defined sclerotico-choroiditis posterior as an untoward complication, which may prove dangerous if the eye be not carefully watched, and its increase guarded against by care and moderation in reading, writing, engraving, &c., and by abstaining as much as possible from all pursuits that tend to produce congestion of the eye.

Prognosis. This should be always very guarded when the disease is at all advanced, when the myopia is progressive, when the vitreous opacities are considerable. It becomes still more questionable if the choroidal changes make their appearance about the macula lutea, if the vitreous opacities are very diffuse, and if the upper or lower portion of the field of vision becomes clouded, for the latter is premonitory or symptomatic of detachment of the retina.

Treatment. Patients suffering from sclerotico-choroiditis posterior should be particularly warned against working for any length of time at near objects, or with their head bent forward, for venous congestion within the eye is thus easily produced. It is also very injurious to read in a recumbent position. The best posture for reading is to sit with the head well thrown back, and to have the light falling on the book from behind, so that the page may be well illuminated, but the eye not exposed to the direct glare of the light. In

writing it is advantageous to use a sloping desk, so that the person need not stoop. If these patients are allowed spectacles for reading, &c., we must also point out the danger of bringing the object too near when the eye gets a little tired. The work or book should then be laid aside until the eyes have been thoroughly rested. In extreme cases we should strictly forbid all work at near objects, either with or without spectacles.

The showers of bright stars and flashes of light are most relieved by flying blisters behind the ears. They may be applied at the interval of six or eight days. For this purpose blistering tissue is the most convenient application.

The "dazzling," of which many of these patients complain when in a bright sunlight or at the sea-side, may be effectually alleviated by cobalt blue spectacles. It was formerly supposed that the red rays of light were the most annoying and trying to the eye, and consequently green glasses (which exclude the red rays) were much in vogue. Now, however, it is a well known fact that it is not the red but the orange rays which are irritating to the retina; and as blue excludes the orange rays, this is the proper colour for such spectacles. Another explanation of the benefit of blue glasses in such cases is that the blue colour, on account of its more excentric position in the sun spectrum, makes a less impression upon the retina. London smoke glasses are now much worn and highly recommended in England. They are undoubtedly very serviceable in those cases in which we desire to subdue and diminish, more or less, the whole volume of light and colour, as they produce about the same effect as if we place the

patient in a somewhat darkened room. But this is not generally necessary, or even in fact desirable, in sclerotico-choroiditis posterior, for we only want to cut off the irritating orange rays, which appear to contribute but very little, if indeed at all, to our power of distinction, for we can read just as far with blue spectacles as with the naked eye, which is by no means the case with smoke glasses. The tint of the blue spectacles should not be too dark.

The feeling of heat in and around the eye is best allayed by evaporating lotions and the frequent use of the eye-douche.

I have found the following lotion of Mackenzie's the most grateful and pleasant to patients :—

℞. Aceti aromatici, guttas quinque
Spiritus ætheris nitrici, drachmam
Aquæ uncias quinque et drachmas septem.
Misce.

Pour out half a wine glassful of this fluid ; with a small piece of clean soft sponge dipped in it, and gently wrung, bathe the eyelids, side of nose, eyebrow, forehead, and temple for a few minutes, and then allow those parts to dry of themselves. Repeat this three or four times daily, or as often as the eyes feel painful, hot, or weak on exposure to light. The fluid does not require to go into the eye.

The eye-douche will be found still more beneficial. The best and cheapest is the one commonly used abroad. It is to be employed night and morning, or, if the eyes feel hot, oftener, for two to three minutes. The eye is to be closed, and the stream is to play gently

upon the closed eyelids. The water should not be too cold.

If the parenchymatous changes in the choroid are at all considerable we should always subject the patient to a prolonged course of small doses of bichloride of mercury ($\frac{1}{20}$—$\frac{1}{24}$ of a grain twice or thrice a day). In this, as in all the inflammatory changes in the choroid, its beneficial effects are generally very marked. Iodide of potassium is indicated if there is any syphilitic or scrofulous taint. As the patients frequently suffer from biliary and venous congestions, their general health must be particularly attended to, for we generally find in this disease that the state of the eyes is much affected by that of the general health. Derivatives acting on the skin and kidneys, hot stimulating foot-baths at night, &c., often prove very beneficial.

But of all remedies artificial leeching (Hœurteloup's)* is that from which most good is to be expected. In order to act upon the intra-ocular circulation it is necessary that the depletion should be rapid, for we find in chronic inflammations of the inner tunics of the eye depletion by leeches to be perfectly useless, whereas the effect of artificial leeches is very considerable. The instrument should be applied to the temple, and a tolerably deep incision made, so that the blood may flow freely and rapidly, without the necessity of any excessive "suction." One or two cylinders full (about one or two ounces) are to be abstracted, according to

* This instrument, as well as the best form of eye-douche, with instructions for their use, may be obtained of Mr. Pillisher, optician, 88, New Bond-street.

the requirements of the case. The screw should not be turned too quickly, as this often produces excessive pain; with a little practice the operation may be gently, yet effectually performed without any suffering. Hot fomentations should be applied afterwards, so that there may be free after-bleeding. As the abstraction of blood near the eye always causes considerable increase in the flow of blood to that part and its vicinity, the depletion should always be made late in the afternoon, so that the patient may retire to rest directly afterwards, and he should be kept in a darkened room till the next afternoon. At first he will see a little dimly, but after 30—36 hours the beneficial effect of the bleeding will generally be very marked.

Although we may alleviate most of the symptoms above mentioned by means of constitutional treatment, together with great rest of the eyes, artificial leeches, the eye-douche, &c., there are yet some cases in which, on account of some peculiarity of constitution, or extreme debility, the best and most reliable of these remedies may be inapplicable, and we can then only prescribe the patient rest, confidence, and hope. But how few are there whose common sense is sufficiently strong, whose confidence in their medical attendant is sufficiently firm to await in apparent inactivity a more favourable turn in their disease? Many patients of this class run about from one oculist to another, until their minds are so unsettled by, may be, conflicting advice (professional and non-professional) that their state of anxiety and nervousness really becomes pitiable.

CHAPTER VI.

PRESBYOPIA.

The presbyopic patient (who is generally above forty years of age) complains that his sight, particularly in the evening, is beginning to fail him for near objects, small print, &c.; at a distance he can, however, see perfectly. In order to see minute objects more distinctly, he removes them further from the eye, or even, perhaps, seeks a bright light, so as to diminish the circles of dispersion upon the retina by narrowing the area of the pupil. But as, on account of the distance at which these fine objects are held, their retinal images are very small, he will soon experience a commensurate difficulty in clearly distinguishing them, and feel the want of spectacles.

In pure presbyopia the far point is at a normal distance from the eye, parallel rays are united upon the retina, and neither concave nor convex glasses (even after the instillation of atropine) at all improve distant vision. The eye is neither myopic nor hypermetropic. There is in fact no anomaly of refraction, but only a narrowing of the range of accommodation; the near point is removed too far from the eye, and hence the difficulty of accurately distinguishing small objects.

Presbyopia is, however, often accompanied by amblyopia (weakness of sight) and the latter is sometimes mistaken for it ; this may the more easily occur, as the amblyopic patient also cannot see small objects distinctly and as convex glasses improve his vision by affording him larger retinal images. In a purely presbyopic eye, (which is free from amblyopia) we should, by means of the proper convex glass, be able to restore a normal sharpness of vision and a normal range of accommodation. With this glass the patient should be able to read No. 1 of Jäger at a distance of about 8″. If he cannot do this, but only perhaps decipher Nos. 4 or 6, or if he is obliged to hold the object very near his eye (nearer than is warranted by its size), he is not only far-sighted but also amblyopic. It may therefore be laid down as a practical rule that the nearer we can approximate, by means of convex glasses, the vision and range of accommodation of a presbyopic eye to that of a normal one, the less is the impairment of sight due to amblyopia, and *vice versâ*.

Donders has found that in the normal (emmetropic) eye the near point gradually recedes, even from an early age, further and further from the eye, and that, in consequence of this, vision of very minute objects becomes proportionately more and more difficult. This recession of the near point commences already about the tenth year, and progresses regularly with increasing age. At forty it lies at about 8″ from the eye, at fifty at 11″—12″ and so on. In the normal eye no inconvenience or annoyance is experienced from this recession till about the age of forty or forty-five.

This change in the position of the near point is met

with in all eyes,—the emmetropic, the hypermetropic and the myopic (if the latter remains healthy).

But the far point also begins in the normal eye to recede somewhat about the age of fifty, so that the eye then becomes slightly hypermetropic (distant vision being improved by convex glasses). At seventy or eighty years of age, the hypermetropia may $= \frac{1}{24}$, *i.e.*, the patient can see distinctly at a distance with a convex glass of 24″ focus. Donders says that this hypermetropia, which is at first only acquired, may afterwards become absolute; so that the patient is not only unable to accommodate for divergent, but even for parallel rays.

This recession of the near point from the eye, and the consequent narrowing of the range of accommodation, is undoubtedly due to a change in those parts within the eye which are passively changed during the act of accommodation, and not to an alteration in those which through their activity bring about the accommodation. For the ciliary muscle, the active agent of accommodation, is generally normal. Whereas the passively changed organ of accommodation, the crystalline lens, gradually becomes more and more firm with advancing years, and in consequence of this increased firmness, the same amount of muscular action cannot produce the same change in the form of the lens as formerly.

At first we, of course, experience no inconvenience from this gradual recession of the near point; we do not, in fact, notice it until the distance is so considerable that we cannot easily distinguish small objects. When are we, then, to consider an eye presbyopic? Donders thinks this should be done as soon as the near point has receded further than 8″ from the eye: for as soon as this

is the case, patients generally begin to complain that continued work at small objects has become irksome and fatiguing. We, however, sometimes meet with persons with very strong sight, who can read and write for hours without experiencing any inconvenience, even although their near point may be 11″— 12″ from the eye. But these cases are exceptional. Let us, therefore, with Donders, consider presbyopia to begin when the near point is removed further than 8″ from the eye.

The degree of presbyopia may, according to Donders, be easily found thus :—If $p > 8'' = 8 + n$, presbyopia, $Pr = \frac{1}{8+n} - \frac{1}{8}$.

This simply means that we are to deduct the near point (8″) at which we consider presbyopia to commence from the presbyopic near point. If, for instance, the latter lies at 12″ it would be $\frac{1}{12} - \frac{1}{8} = -\frac{1}{24}$. $Pr = -\frac{1}{24}$. Again, if it lies at 16″ it is $\frac{1}{16} - \frac{1}{8} = -\frac{1}{16}$. $Pr = -\frac{1}{16}$. We have, at the same time, found the number of the convex glass, which would bring the near point back again to 8″. In the first case, it would be convex 24 ; in the last, convex 16.

The reader will have been struck by the fact, that if we consider an eye presbyopic when the near point is removed further than 8″ from the eye, not only the emmetropic (normal), but even the myopic or hypermetropic eye may suffer from presbyopia. If, for instance, a short-sighted person suffers from a myopia $= \frac{1}{16}$ (his far point lying at 16″ from the eye), and his near point lies at 12″, he is both short and long-sighted. His myopia $= \frac{1}{16}$, his presbyopia $= \frac{1}{24}$. This cannot, of

course, occur when the myopia is considerable, *e.g.*, $\frac{1}{6}$ (the far point lying at 6″ from the eye).

In hypermetropia the same thing may happen.

If with the convex glass—which neutralizes the hypermetropia, which renders the hypermetropic eye capable of uniting parallel and divergent rays upon the retina—the near point lies at 12″ from the eye, the patient is not only hypermetropic, but also presbyopic. He will require two different sets of convex spectacles, one pair which will enable him to see from 12″ to infinity, and another stronger pair which will bring his near point nearer than 12″.

The range of accommodation of a presbyopic eye is easily found by the formula $A=\frac{1}{p}-\frac{1}{r}$. If such an eye can see from 10″ to infinity (∞), its near point (p) will lie at 10″, its far point (r) at ∞, its range of accommodation, therefore, $=\frac{1}{10}-\frac{1}{\infty}=\frac{1}{10}$. $A=\frac{1}{10}$.

There can be no question as to the advisability and necessity of affording far-sighted persons the use of spectacles. They should be furnished with them as soon as they are in the slightest degree annoyed or inconvenienced by the presbyopia. Some medical men think that presbyopic patients should do without spectacles as long as possible, for fear the eye should even at an early period get so used to them as soon to find them indispensable. This is, however, an error, for if such persons are permitted to work without glasses we observe that the presbyopia soon rapidly increases.

It has been already stated how the proper glasses may be readily calculated. If p (the near point) lies 16″ from the eye, $Pr=\frac{1}{16}-\frac{1}{8}=-\frac{1}{16}$. A convex glass of 16″ focus will bring the near point back again to 8″

from the eye. We must generally, however, give somewhat weaker glasses, because, on account of the greater convergence of the optic axes, the near point will through these glasses (convex 16) be in reality brought nearer than 8″. Late in life, when there is some diminution in the acuteness of vision (Sehschärfe), Donders thinks that the near point should sometimes be brought even to 6″ or 7″, and that it should be brought the nearer the greater the range of accommodation.

He further thinks that when no hypermetropia exists, the weakest glasses with which No. 1 of Jäger can be distinctly and easily read at about 12″ distance may generally be given.

In choosing spectacles for far-sighted persons we must also be particularly guided by the range of their power of accommodation. If this is good, we may give them glasses which bring their near point to 8″ ; but if it is much diminished weaker glasses should be chosen, so that it may lie at 10″—12″ from the eye.

In conclusion I may be allowed to call the reader's attention to the very important fact that a very rapid increase of presbyopia is one of the premonitory symptoms of glaucoma. If, therefore, a patient tells us that his far-sightedness has rapidly increased within a few months, so that he has had repeatedly to change his spectacles during that time for stronger and stronger ones, our suspicions should be aroused, and we should without fail examine him as to the presence of other premonitory symptoms of glaucoma,—*e.g.*, rainbows around the candle, periodical obscurations, &c. Von Græfe thinks that this rapid increase of presbyopia is most likely due to an increase of intra-ocular pressure and flattening of the cornea.

CHAPTER VII.

HYPERMETROPIA.

We have now to turn our attention to an affection which was but little noticed, certainly not properly understood, until the last few years. Von Græfe was the first to describe it accurately and scientifically;* and since then Donders' elaborate researches have shown how common this affection is, and how very frequently that peculiar weakness of sight, which has received so many various names, and whose nature was so little understood, viz., asthenopia, is due to it. The affection I speak of was first called hyperpresbyopia, but it was soon found that it may, and generally does, exist without any presbyopia at all, and that therefore this name was most inappropriate. It was then termed hyperopia; this term is better, but Donders now proposes to call it hypermetropia, which is undoubtedly the best name for it, and should therefore be generally adopted.†

By hypermetropia is meant that peculiar condition of the eye in which the refractive power of the eye is too low, or the optic axis (the antero-posterior axis) too short; we may, however, also have both these causes

* Græfe's "Archiv. für Ophthalmologie," II. i. 179.

† It may also be called over-sight.

co-existing. We may often almost diagnose the hypermetropic eye by its peculiar shape, it appears flatter and smaller than the normal eye, it does not fill out the aperture of the lids, there being a greater or less space (like a little pouch) between the eyeball and the canthus, more particularly the outer canthus.

The effect of the too short optic axis, or the too low refracting power of the eye is that the focal point of the dioptric system lies behind the retina, so that in a state of rest even parallel rays are not brought to a focus upon the retina, but behind it, and only convergent rays are united upon the latter.

The normal (emmetropic) eye unites parallel rays upon the retina without almost any (if any) effort of accommodation, but it also possesses the power of accommodating itself without difficulty or annoyance for divergent rays, coming from objects 6″ — 8″ from the eye, for a short time it can even unite rays upon the retina which come from 3″ — 4″ distance. The focal point of the dioptric system lies in the normal eye exactly upon the retina, Fig. 1.

In the myopic eye, it will be remembered, the state of refraction is too great, or the optic axis too long, so that when the eye is in a state of rest the focus of the dioptric system lies in front of the retina, and parallel rays (emanating from objects at an infinite distance) are brought to a focus before the retina, and only more or less divergent rays are united upon the latter, Fig. 5.

Now, in hypermetropia we have just the reverse of this. The refractive power of the eye is so low, or its optic axis so short, that when the eye is in a state of rest, parallel rays are not united upon the retina, but

behind it, and only convergent rays are brought to a focus upon the latter. We therefore give the slightly divergent, almost parallel rays emanating from distant objects a convergent direction by means of a convex glass, and the reader will now see how it is that a hypermetropic eye requires convex glasses for seeing distant objects. The patient may require perhaps even a stronger pair for near objects. The consequence of this low refractive power of the eye is, that whereas the normal eye unites parallel rays upon its retina without any accommodative effort, the hypermetropic eye has already, in order to do so, to exert its accommodation more or less considerably, according to the amount of hypermetropia. This exertion increases, of course, in direct ratio with the proximity of the object. If the degree of hypermetropia is moderate, and the power of accommodation good, no particular annoyance is perhaps experienced, even in reading or writing. If, however, the hypermetropia is absolute, the patient will not be able to see well at any point.

Fig. 10.

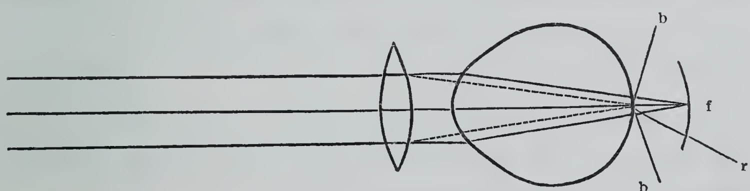


Fig. 10 represents a hypermetropic eye, in which either on account of its being too short in the antero-posterior axis, or its possessing too low a power of refraction, parallel rays are brought to a focus, not upon

the retina (r), but behind it at f; circles of dispersion (b b) are formed upon the retina, and the object consequently appears blurred and indistinct. To remedy this the eye undergoes a change in accommodation, so as to increase its power of refraction sufficiently to unite the parallel rays at r. The less the power of refraction of the hypermetropic eye the greater must this effort of the accommodation be, and must increase, of course, proportionately as the object is brought nearer to the eye. By placing a suitable convex lens before the eye the parallel rays are rendered so convergent that they are united upon the retina (r) without any effort of accommodation, and we thus place the hypermetropic in the same condition as the normal eye, upon whose retina parallel rays are united without almost any effort of accommodation.

We must not be surprised at the fact that persons suffering from hypermetropia are often not aware that they see worse at a distance than other people. On the one hand, but few people have to look for any length of time at distant objects, and on the other hand the aspirations of some are so modest, that they fancy they enjoy capital sight if they can distinguish between a church and a house across a street. It is different, however, with near objects; a person soon finds out if he cannot read or write for a continuance without difficulty and annoyance.

We sometimes meet with normal eyes which not only see perfectly near at hand and at a distance, but are capable of relaxing their power of accommodation to such an extent that they can unite convergent rays upon the retina, being able to see at a distance

with slightly convex glasses. Their eye is then hypermetropic. Donders calls this *facultative* hypermetropia.

Let us now consider how we are to examine a person as to hypermetropia. After I have explained this, we can more easily pass on to the consideration of other questions connected with this affection.

The patient usually complains that, after he has been reading or writing for a short time, the letters become ill-defined, and appear to run into each other. At a distance, however, he says he can see perfectly.

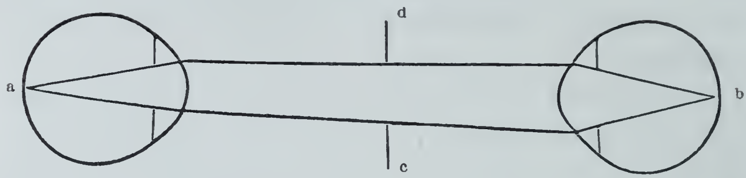
His eye appears smaller and flatter than a normal eye ; it does not fill out the palpebral aperture properly ; there is a little space between the outer canthus and the eyeball. Upon turning the eye very much inwards the posterior portion of the eyeball is seen to be flatter and less rounded than it should be.

OPHTHALMOSCOPIC DIAGNOSIS OF HYPERMETROPIA.

The ophthalmoscope also enables us to diagnose a hypermetropic eye, but in this case just the reverse obtains to what was seen in the myopic eye. (Page 32.)

I. The fundus may also in this case be seen in the erect image at a considerable distance, but we obtain an erect image of it (and not as in myopia a reverse image), for if we regard the optic nerve, or one of the retinal vessels, and move our head to one side, we find that the image *moves in the same direction.* For an explanation of this let us glance at Fig. 11.

FIG. 11.



Let a be the hypermetropic eye, b the eye of the observer, a is adjusted for its far point (convergent rays), and the rays from its fundus consequently fall in a divergent direction upon the observer's eye. If the latter is myopic (adjusted for divergent rays) the rays will be united upon his retina without the aid of any correcting lens behind the ophthalmoscope. But if his eye is normal (adjusted, when in a state of rest, for parallel rays) he will either have to place a convex lens behind the mirror, or have to accommodate for a nearer point.

The image of the observed eye will be erect, for c and d retain their relative positions.

II. On going closer, but still examining in the erect image, the field of vision appears much enlarged, and the image removed further from the eye, its size is much diminished, whereas the intensity of its light and colour is much increased. If the hypermetropia is considerable we can overlook at a glance not only the whole optic entrance, but also a considerable portion of the fundus around it. If our eye is normal, we shall have either to place a strong convex lens behind our mirror, or else we must accommodate for a nearer point, in order to gain a distinct image.

We tell the patient to read No. 20 of Jäger's test-types placed at a distance of eighteen to twenty feet, so

that the rays, as they impinge upon the eye in an almost parallel direction, may be considered as coming from an infinite distance. He can read No. 20 very well without any glass, and even No. 19 somewhat indistinctly. Now, a normal eye should, at this distance, be able not only to read No. 19 fluently, but even No. 18, and words of No. 16. We now place a weak convex glass of 36 or 40 inches focus before his eyes; this improves vision somewhat; we try a stronger glass, and find at last that convex 20 improves most of all; with it he can read No. 18; the letters appearing clearer and well defined—convex 16 is not so good—No. 20 is therefore the strongest convex glass with which he can see well at a distance; and this, according to Donders, give us the degree of hypermetropia, which is consequently $= -\frac{1}{20}$. Each eye should be tried separately, as the degree of hypermetropia may vary. We now let the patient read very small print with convex 20, and find that he can read No. 1 of Jäger clearly and distinctly as close as 7″ from the eye; his range of accommodation is therefore good.

If we, however, prescribed convex 20 for the patient, and told him that these spectacles would permanently free him from all annoyance in reading, writing, &c., and that he would not, after a time, have to change them for a stronger pair, we might commit a grave error, and subject ourselves to the vexation of having him return to us in the course of a few weeks with the complaint that the glasses we chose for him did not suit; that, although they enabled him to read or work for a longer time than before, he could not go on for any length of time without being troubled by symptoms of asthenopia.

Now, into what error should we have fallen here? Simply into that of having given him spectacles which were too weak, which did not neutralize his hypermetropia.

The fact is that the patient has been so accustomed to exert his accommodation even when regarding distant objects (in doing which the normal eye has hardly to accommodate at all), and that this exertion of the accommodation has become so habitual that he cannot relax it completely, even when there is no occasion for it, when the malconstruction of his eye is compensated for by the use of a convex lens. With convex 20 he did not therefore accommodate for his natural far point, but for a nearer point, as he could not relax his accommodation sufficiently. We have therefore arrived at too low an estimate of the degree of his hypermetropia. In order to find out its real amount we must paralyse the power of accommodation by the instillation of a strong solution of atropine. Donders has found that in order completely to paralyse the muscle of accommodation,* a solution of 4 grains of atrop. sulph. to 1 ounce of water is necessary, and that it takes about two to three hours to act thoroughly. A weaker solution of 1 grain to 2000 parts of water suffices to dilate the pupil widely, but only partially paralyses the ciliary muscle.

After the instillation of a strong solution of atropine, we, after the lapse of a couple of hours, again examine our patient. We now find that he cannot read No. 20 (at 20 feet distance) at all without glasses. A

* This muscle has received various names, viz., tensor choroidæ, ciliary muscle, and Brücke's muscle.

normal eye would be able to do so, would, indeed, according to Donders, become but very slightly hypermetropic after atropine, requiring, perhaps, only convex glasses of 80 or 60 inches focus to see more distinctly at a distance. In our patient, however, the difference in the degree of hypermetropia, before and after atropine, is great. Whereas he could before its application see distinctly at a distance with convex 20, he now requires convex 8. And we now see, from the difference of the strength of the glasses required before and after atropine, to what extent he still exerted his accommodation in looking at distant objects, before we had paralysed his power of accommodation by atropine. Donders, however, points out the fact that only in young persons, with a good range of accommodation, is the difference in the degree of hypermetropia before and after atropine so great. In more advanced age, and in young persons with a smaller range of accommodation, the difference is much less. We should only put the atropine into one eye at a time, else we render the patient incapable of working for several days. After the effect of the atropine has gone off completely (which sometimes takes six or seven days) we apply it to the other eye. This precaution is the more necessary in the case of poor hospital patients, to whom the loss of a few days' work is of consequence.

Hypermetropia is very frequently latent. If its degree is but slight, it is often perfectly latent till the age of twenty-five or thirty, when symptoms of asthenopia begin to show themselves, if the patient is obliged to work for any length of time at near objects. Our suspicion is aroused by these symptoms, and on

placing a convex glass before his eyes, we find that he can distinguish distant objects far better than without it. If the glasses be only momentarily held before the eyes, the existence of hypermetropia may escape us, for the patient has been so accustomed to exercise his power of accommodation, even for distant objects, that he cannot at once relax his accommodation. But if he continues to look through the glasses for a few minutes, he gradually finds that the distant objects become more and more distinct, and clearly defined. In order to make sure to what degree the hypermetropia exists, and to what extent the person is obliged to exercise his accommodation in looking at distant objects, we must paralyse his power of accommodation by the instillation of a strong solution of atropine.

The hypermetropia may be so great that it is never latent, even in childhood it makes itself felt, and vision of distant objects is improved by convex glasses. In these cases it is always accompanied by a diminution in the range of accommodation, and on this account, even at an early age, two pairs of spectacles will often be necessary, a stronger pair of convex glasses for reading, writing, &c.; a weaker pair for distant objects.

It is a curious fact that when the hypermetropia is considerable, the patient can often read better when the print is only a short distance from the eye than when it is 10″—12″ off. Von Græfe thinks this is due partly to the diminution in the size of the pupil which takes place on looking at small objects, for the area of the pupil being smaller, some of the peripheral rays are cut off, and there is consequently a diminution in the circles of dispersion on the retina. He has also shown

that on approximating an object to the eye, the circles of dispersion on the retina in a hypermetropic eye increase comparatively less in size than the size of the retinal images. In consequence of this, there is more chance of interspaces between the letters when the print is held at a distance of 5″ — 6″ than at 10″ — 12″. At the latter distance, there would not be so much difference between the size of the retinal images and the circles of dispersion, so that the letters would appear more confused and indistinct. But besides these reasons, the greater amount of convergence, and consequent increase in the action of the power of accommodation, has most likely some influence in enabling the patient to see better at a distance of 5″ — 6″.

When speaking of presbyopia, we mentioned that according to Donders the near point begins to recede from the eye at about ten years of age, and that this recession continues uninterruptedly to advanced age. He has found that the far point remains stationary till about the age of forty or forty-five, then it gradually recedes from the eye ; at fifty-five or sixty this is distinctly evident in the originally normal eye, the eye has become hypermetropic, and a convex glass is necessary for distinct vision of distant objects. But this differs much in different individuals. At seventy or eighty years of age the hypermetropia often $= \frac{1}{24}$. Donders considers that this recession of the far point—this diminution of refraction—is due to changes in the structure of the lens, which becomes firmer and more consistent, and its surface somewhat flatter with advancing years.

We have seen that the near point also recedes from

the eye, that at the age of forty-five it was about 9″ — 10″ from the eye, and we followed Donders in considering presbyopia to commence when the near point was removed further than 8″ from the eye. A hypermetropic eye may therefore at a certain age become presbyopic; or again, an originally normal eye may become presbyopic at the age of forty-five, and hypermetropic at fifty or sixty, so that we may have presbyopia and hypermetropia co-existing in the same eye. If, with the glasses which neutralise his hypermetropia, a hypermetropic patient cannot read very small print nearer than 12″—14″ from the eye, he is also presbyopic. Let us suppose that convex 16 is the glass which neutralises his hypermetropia, which enables him to see distant objects distinctly without any effort of accommodation; on telling him to read No. 1 of Jäger with this glass we find that the nearest point at which he can do so with ease is 12″. The amount of presbyopia therefore $= \frac{1}{24}$; and as convex 16 is the glass which neutralises his hypermetropia, the latter $= \frac{1}{16}$, and he will require convex 16 for objects lying between 12″ and infinity, and a stronger glass to bring his near point near than 12″. This is easily found by the equation $\frac{1}{f} = \frac{1}{24} + \frac{1}{16} = 9\frac{3}{5}$. But convex 10 would, on account of the influence of the convergence of the optic axes, be found somewhat too strong. Hence convex 12 would most probably be the fitting glass.

The range of accommodation of a hypermetropic eye is easily found. We must first change it into a normal eye by furnishing it with that convex glass which will enable it to see distant objects distinctly without almost

any exercise of the accommodation; and then, still wearing this glass, find the nearest point at which it can read No. 1 distinctly and easily. If the patient requires for distant vision convex 20 before the instillation of atropine, and convex 10 after it, we should try his nearest point with a glass between the two—No. 16 for instance,* for No. 10 would be too strong. He has been so accustomed to strain his accommodation that he cannot all at once really command his near point with convex 10.

Let us now suppose that with convex 16 his near point (p) lies at 7″; his far point (r) has been found to be at an infinite distance (∞); for he can see distant objects well with convex 16 without much effort, although convex 20 is best. This range of accommodation (A) is to be found by the formula $A = \frac{1}{p} - \frac{1}{r}$. Now, $p = 7''$, $r = \infty$, hence $A = \frac{1}{7} - \frac{1}{\infty} = \frac{1}{7}$. His range of accommodation $= \frac{1}{7}$.

When we have gradually accustomed the eye to the use of stronger and stronger glasses for distant vision, and have finally gone over to the use of the glass which completely neutralises the hypermetropia (which is convex 10 in our supposed case), we may try the range of accommodation again with this glass.

I must again remark that this plan of finding the range of accommodation is not mathematically exact. But it is by far the simplest and quickest proceeding, and sufficiently accurate for all practical purposes. And

* I need not point out the necessity of waiting until the effect of the atropine is thoroughly gone off, which may take five or six days, before testing the range of accommodation.

as my object in these papers is to make the subject of which I am treating as simple and practical as possible, I have purposely abstained from entering into elaborate formulæ, and somewhat intricate questions and calculations.

Let us now consider the method of suiting hypermetropic patients with spectacles.

We must first discover the amount of the hypermetropia before atropine, by letting the patient read No. 19 or 20 of Jäger at a distance of 20 feet. Let us suppose that convex 20 is the strongest glass with which he can read No. 19 fluently and distinctly. His hypermetropia before atropine therefore = $\frac{1}{20}$. We then try the nearest point at which he can read No. 1 comfortably; this is found to be 7″. He is therefore not presbyopic. In order to find out to what extent he has strained his accommodation in reading No. 19 through convex 20, and to know what glass will completely neutralise the hypermetropia, we paralyse his power of accommodation—his ciliary muscle—by the instillation of a strong solution of atropine (gr. iv. to the ounce of water). After this has acted for a couple of hours we examine the patient again. He cannot now read No. 20 without a glass, or even with convex 20; but now requires convex 10 for reading No. 19 fluently. The real amount of hypermetropia therefore = $\frac{1}{10}$. He has, however, been so accustomed to strain his powers of accommodation that he could not relax it completely, even when there was no occasion for accommodating at all, when we corrected the malconstruction of the eye by means of a convex glass.

What spectacles are we to give him?

If we were to prescribe convex 10 they would be

found too strong for distant objects, or even perhaps for reading. He could not all at once relax his accommodation, so as to be able to use the glasses, which really neutralise his hypermetropia, and which must ultimately be used if we wish to free him permanently from the annoyances of his affection. We must therefore gradually accustom his eyes to stronger and stronger glasses, until convex 10 be reached. Let us begin with convex 18 or 20. He is to wear them both for reading, writing, and distant objects. Never, indeed, laying these spectacles aside when he is using his eyes. In the course of a few weeks we give him convex 16, then 14, 12, and, at last, after the lapse of a few months, he can wear No. 10 for reading and for distance.

I have occasionally, however, found that it was almost impossible to persuade hypermetropic patients to assume spectacles for distance; they see well without them, and either on account of personal appearance, or because they think there is no necessity for their use, refuse to wear them. They are, however, always but too glad to avail themselves of the proper, sufficiently strong convex glasses for near objects, finding that by their aid they effectually avoid all symptoms of asthenopia. I have met with other patients who had to be very gradually accustomed to the use of convex glasses for distance; if, for instance, convex 30 was the strongest glass with which such a patient could see at a distance before atropine, and convex 12 was required after atropine, I was obliged to commence with perhaps convex 40 or even 50 at first, and gradually, but slowly, weeks elapsing between each change, to exchange them for stronger and stronger ones, until convex 12 was

finally reached. If this was not done, or if the patient began perhaps at once with convex 30, he experienced great discomfort, a sensation of straining within the eye, and pain around the orbit, and was forced to lay aside the spectacles.

When the degree of hypermetropia is great, or when presbyopia co-exists, two sets of spectacles will be required, a strong pair for reading, writing, &c., a weaker pair for distant objects.

Having considered the symptoms, diagnosis, and treatment of hypermetropia, let us now, in conclusion, glance at two affections of which hypermetropia is very frequently the cause, viz., asthenopia and convergent strabismus.

The former of these affections has received a great variety of names, asthenopia, hebetudo visus, impaired vision, muscular amaurosis, &c. &c. It presents the following symptoms : The patient cannot continue to regard near objects for any length of time, as in reading writing, &c., without the eyes becoming fatigued. The print becomes confused and indistinct, the letters run into each other ; there is a feeling of tension about the eye, which, if the work is persisted in, soon becomes more intense, and sometimes even assumes the character of headache, (which is often mistaken for nervous headache, or migraine ;) the eye at the same time perhaps watering, becoming red, and feeling hot and uncomfortable. Yet there is nothing in the appearance of the eye to warrant this state of things. It looks perfectly normal, the refracting media are clear, vision is good, the convergence of the optic axes perfect, the mobility of the eye unimpaired. Neither does the oph-

thalmoscope reveal anything abnormal, except perhaps a slight state of congestion of the retina and choroid. And yet the eye is perfectly useless for continued work at near objects, for reading, writing, sewing, engraving, &c.; for the symptoms of asthenopia soon show themselves, and the work has to be laid aside. Then these symptoms quickly vanish, and the occupation can be resumed until the reappearance of the annoying symptoms again necessitate an interval of rest, the longer this is, the longer will the person be able to re-continue his employment.

All ophthalmologists know from experience how wearisome such cases mostly prove in the treatment, and how unsatisfactory the result generally is after the whole routine of remedies has been gone through. Purgatives, sedatives, tonics, counter-irritants, alteratives, &c., their name is legion! But yet how futile do they not almost always prove in curing this affection. But why do they prove futile? Because in the great majority of cases the asthenopia is not dependent upon any overwork of the eyes, or upon general debility, but either upon hypermetropia or upon an insufficiency of the internal recti muscles of the eye.

It was, indeed, a great boon when Donders discovered that most of these cases of asthenopia depended upon hypermetropia, and might, therefore, be permanently cured by the proper use of convex glasses. Since he first called the attention of the Profession to this important fact, I have examined a great number of persons suffering from asthenopia, and have found his statements, in all respects, completely verified.

It will be remembered that in the hypermetropic

eye the antero-posterior axis is too short, or the refracting power too low, so that parallel rays are, when the eye is in a state of rest, not brought to a focus upon the retina, but behind it; consequently it already requires an exertion of the power of accommodation to unite even parallel rays upon the retina. But how much greater must this exertion become when strongly divergent rays (as in reading, writing, &c.) are to be focussed upon the retina! The consequence is, that the eye cannot keep up this great strain of its power of accommodation —its ciliary muscle—for any length of time, and hence this inability to continue working at near objects for any long period; hence also the whole train of asthenopic symptoms.

It does not, however, follow that all cases of hypermetropia must of necessity be accompanied by asthenopia. It may be absent if the range of accommodation is good, and the degree of hypermetropia but slight. When the degree of hypermetropia is great, asthenopia is always present.

The existence of hypermetropia may sometimes be overlooked in these cases, if it is but slight, or if the convex glasses are only momentarily held before the eyes. We should, therefore, in all cases of asthenopia (which do not belong to the next category), paralyse the power of accommodation by the instillation of a strong solution of atropine. The reason of this proceeding I have already fully explained in a former paper.*

In these cases of asthenopia dependent upon hyper-

* See p. 88.

metropia we sometimes find, with the ophthalmoscope, that the choroid and retina are somewhat congested. And I have known patients in whom this was the case strongly advised to abstain from all work, and particularly to eschew the use of spectacles. If there is much congestion, it would be as well to rest the eyes for a short time, to use the eye-douche, &c.; but generally the congestion is but very slight, and is to be removed and prevented by the use of convex glasses. The congestion is, in fact, owing to the overstraining of the accommodative apparatus, and will disappear as soon as the necessity for this over-exertion is removed by the neutralization of the hypermetropia through convex glasses.

I must therefore strongly urge the necessity of the hypermetropic person wearing glasses *always*, for distant as well as for near objects. Thus only can he be perfectly and permanently freed from the discomforts of his affection; for even although asthenopia do not exist at first, it will soon show itself if the hypermetropia be allowed to progress through the non-use of spectacles. We must insist upon his gradually accustoming himself to stronger and stronger glasses, until that number is reached which really neutralizes his hypermetropia, which he required when his power of accommodation was paralysed by atropine.

It has been thought that asthenopia might be cured by gradually accustoming the eye to weaker and weaker glasses, so as finally to render their use altogether superfluous. But the reader will now understand how just the contrary proceeding is necessary in hypermetropia. If we wish permanently to cure the patient,

we must prevent all undue straining of his accommodation, and this can only be done by completely neutralizing his hypermetropia, by the use of that glass which changes his eye into a normal eye, enabling it to see distant objects perfectly without almost any, but the very slightest, action of the power of accommodation.

I would strongly urge the attention of the Profession to the important fact that asthenopia is almost always due to hypermetropia, and that these cases which, under any other course of treatment haunt our out-patient rooms for months and years without relief, may be speedily cured by the proper treatment of their hypermetropia. Let us but consider the crowd of sempstresses, watchmakers, engravers, &c., who are rendered incapable of following their employment, whose future is starvation, if this fact is not attended to!

I have already, when speaking of myopia,* referred to another, but far less frequent cause of asthenopia, viz., insufficiency of the external recti muscles. This frequently occurs in the short-sighted, and may be permanently cured by a tenotomy of the external recti muscles, or by exercises with prisms. I shall, however, in future papers on strabismus, &c., return to this subject.

Donders has also proved that convergent strabismus almost always depends upon hypermetropia. The reason of this is, that with the increase of the convergence of the optic axes there is also an increase in the power of accommodation. This assertion is proved by the fact that if we place a prism (with its base turned outwards)

* See p. 48.

before a hypermetropic eye, the latter will squint inwards in order to avoid diplopia in looking at distant objects, and this convergence will enable the eye to accommodate for parallel rays (distant objects), whereas with parallel optic axes, it before required convergent rays, *i.e.,* the rays from a distant object had to be rendered convergent by means of a convex glass in order to be brought to a focus upon the retina. Again, if we place a concave glass before a normal eye we change it into a hypermetropic one; parallel rays are united *behind* the retina, and it either requires an effort of accommodation, or a convex glass to bring them to a focus *on* the retina. If the concave glass is but of slight power, an increased effort of accommodation, an increase in the convexity of the crystalline lens, will neutralise the effect of the concave lens and overcome this artificial hypermetropia. But if the concave glass is too strong for this, the eye often overcomes its effect by squinting inwards, and thus increasing its power of accommodation. Now the same thing often occurs in hypermetropia; the eye squints inwards in order to increase its power of accommodation. This has been called periodic squinting. In the beginning no deviation of the optic axis is observable as long as the person is not looking sharply at anything; but as soon as he looks intently at any object, near or distant, convergent squint shows itself. Sometimes this only occurs when the eye is looking at near objects, the squint disappearing as soon as the eye regards distant objects. After a time the squint becomes permanent, particularly in those persons who work much at near objects, whether in reading, writing, sewing, &c. We meet with it very frequently

in children about the third or fourth year, when they first look attentively at things, or begin to use their eyes for any length of time for near objects. When this tendency to squint first shows itself it may be corrected by neutralising the hypermetropia by means of convex glasses, but will generally require an operation.

Since Donders first pointed out the connexion between hypermetropia and convergent strabismus, I have made a point of examining a great many cases of squint, and have found that hypermetropia was present in the great majority of convergent squints. The degree of hypermetropia is generally not very great, mostly varying from $\frac{1}{40}$ to $\frac{1}{16}$ or $\frac{1}{12}$.

There are, of course, other causes of convergent squint, such as myopia, paralysis of the antagonist muscle, opacities of the dioptric media, &c.; but I reiterate, that of all these causes hypermetropia is by far the most frequent.

I have stated that in childhood this form of squint often arises, that in order to correct the hypermetropia by a stronger action of its power of accommodation the child involuntarily, unwittingly, squints inwards when it wants to see any object distinctly. This squint soon becomes permanent, the image of the squinting eye is suppressed (in order to avoid diplopia), and its vision is very frequently soon irremediably destroyed, if a timely squint operation be not performed. Yet there is amongst some ophthalmologists a strong opinion that a squint should not be operated upon in childhood. But how erroneous is this advice, how many eyes have not been sacrificed through following it!

If, for instance, a child suffers from hypermetropia,

and squints inwards in order to increase its power of accommodation, this squint will soon become permanent. To avoid diplopia the image of the squinting eye is suppressed by the brain; but this negation of the pseudo-image soon leads to deterioration of sight, and the vision of the squinting eye is gradually greatly impaired, or even sometimes almost completely destroyed. Hence the necessity of operating on a squint as early as possible, whilst the sight is yet good. I have not the slightest hesitation in saying that the sight of the squinting eye would thus be saved in the greater number of (if not, indeed, in all) such cases.

If, after the squint-operation in eyes suffering from hypermetropia, the latter is not neutralised by convex glasses the strabismus may recur, and a relapse take place.

CHAPTER VIII.

PARALYSIS, SPASM, AND ATONY OF THE CILIARY MUSCLE, ETC.

Considerable diminution, or even complete loss of power of accommodation, is occasionally met with. We have seen that the range of accommodation is often greatly diminished in presbyopia, for the near point may have receded to 16″—18″ from the eye, so that the range of accommodation is reduced to $\frac{1}{16}$ or $\frac{1}{18}$, instead of being, as in the normal eye, $= \frac{1}{4}$ or $\frac{1}{5}$. The range of accommodation is also frequently considerably diminished in persons who are very short-sighted, and who have worked much at near objects, so that the ciliary muscle has lost some of its elasticity and become somewhat rigid.

Diminution, or loss of the power of accommodation, is often due to paralysis, spasms, or atony of the ciliary muscle.

The fact that we frequently meet with loss of accommodative power, together with a general or partial paralysis of the third nerve, is of great interest, for it tends to prove that the ciliary muscle is most likely supplied by a branch of the third; this view is now generally accepted, and it is thought that the loss of accommodation is in such cases due to a paralysis of

the branch supplying the ciliary muscle, therefore to a direct paralysis of the muscle itself.

The frequency of loss or diminution of the power of accommodation co-existing with dilatation of the pupil due to the paralysis of the pupillary branch of the third nerve, is of importance in the consideration of the mechanism of accommodation. As long as ophthalmologists, agreeing with Cramer's theory, considered the iris to play a principal *rôle* in the production of the necessary convexity of the lens during near objects, it was supposed that the dilatation of the pupil was the cause of the loss of accommodation. It was thought that the anterior surface of the lens was rendered more convex by pressure of the radial fibres of the iris upon the periphery of the lens. But in order that the iris may exert such pressure, anterior and posterior fixed points are necessary. The contracted sphincter pupillæ (the pupil is, as we have seen, contracted during accommodation for near objects) is the anterior fixed point, the ciliary muscle, which also contracts, the posterior. Now, when the pupillary branch of the third is paralyzed, dilatation of the pupil ensues, the anterior fixed point is lost, the radial fibres can no longer exert a sufficient pressure upon the periphery of the lens, and hence it was argued the loss of accommodation in such cases.

But that the loss of accommodative power does not depend upon the dilatation of the pupil, and consequent inefficient action of the iris, is proved by the following facts :—

1. The accommodation may be paralyzed without any dilatation of the pupil.

2. The pupil may be dilated, from paralysis of the

pupillary branch of the third, without the accommodation being effected.

3. We sometimes find that after the pupil has regained its contractility (after paralysis of the nerve to the constrictor pupillæ), the power of accommodation remains yet for some time impaired.

4. With a weak solution of atropine (1 part to 2000 parts of water) we may dilate the pupil fully without completely paralysing the muscle of accommodation ; in order to do so we must use a strong solution (1 part to 120 of water).

5. That the iris is not of any particular importance in bringing about the accommodative changes of form in the lens, is thoroughly proved by Von Græfe's interesting case of total absence of the iris, in which the power of accommodation was normal.

We must therefore look upon the ciliary muscle as the principal, if not the sole, factor in producing the necessary changes in the form of the lens during accommodation.

Occasionally the branch to the ciliary muscle is alone paralysed, all the other branches of the third being intact. This isolated paralysis of the branch to the ciliary muscle sometimes co-exists with paralysis of other nerves, particularly of branches of the facial nerve. Paralysis of the ciliary muscle is at times due to cerebral causes ; indeed, mydriasis, with loss of accommodation, is not an unfrequent precursor of cerebral affections. It is at times due to syphilis, congestion, &c.

Diminution or loss of accommodation is occasionally met with after severe illnesses, the whole muscular

system being greatly debilitated, and it is then often mistaken for amblyopia, or weakness, of sight, dependent upon general debility. Mr. George Lawson has lately reported some interesting cases of this form of loss of accommodation.*

We find that a considerable amount of asthenopia is sometimes produced by over-exertion of the eyes at near objects. The asthenopia does not, in this case, depend either upon hypermetropia or insufficiency of the internal recti muscles, but simply upon fatigue of the muscle of accommodation, through continued work at near objects : this state being, in fact, analogous to that produced in other muscles by long-continued over work. In order to treat this form of asthenopia effectually, total rest of the eyes is essentially necessary, and a complete abstinence from all accommodative exertions must be enforced. The patient should, therefore, be supplied with convex spectacles of sufficient strength to render rays, emanating even from very near objects, parallel, *i.e.*, as if they came from distant objects (from the far point) ; thus there will be no exertion of the accommodation during reading, writing, &c. After these spectacles have been used for some time, Von Græfe advises that the eye should be methodically exercised as to its accommodation, by gradually accustoming it to weaker convex glasses, the distance of the object remaining the same. The spectacles should be of a blue tint, in order to diminish the irritation of the retina, which has, in most cases, been produced by the circles of dispersion, caused by the inefficient action of the accommodative apparatus.

* Lancet, vol. i., 1861.

We may also rest the accommodation by paralysing the ciliary muscle with a strong solution of atropine.

Loss or diminution of accommodation, dependent upon spasm of the ciliary muscle, is, according to Von Græfe, exceedingly rare. Distinct vision is, in these cases, limited to the near point, or may lie even on this side of it. The patient is myopic ; but for every variation in the distance of the object a different concave glass will be required.

Dr. Liebreich has recently reported a most interesting case,* in which the patient was apparently suffering from myopia, requiring concave glasses for distant objects ; but there was really no myopia, but hypermetropia together with spasm of the ciliary muscle.

The patient could only see distinctly, with either eye, or with both together, at 6″ ; nearer, or further off, the object became indistinct. But for distant objects she required concave 40, and not, as might have been supposed from the apparent amount of myopia, concave 6 or 7. When looking at distant objects the eyes were consequently accommodated for 40″, and yet an object at the latter distance could not be seen distinctly with the naked eye, but only with concave 50. On approximating the object gradually to the eye, stronger and not weaker concave glasses (varying from No. 50 to 40) were required : even at 7″ distance the object could only be distinctly seen through concave 40 ; whereas, at 6″ it was best seen with the naked eye, the weakest concave or convex glasses rendering it indistinct. With convex 10 she could only see it distinctly at 4″, neither nearer nor further off.

* Von Græfe's Archiv., VIII., 1, 259.

Dr. Liebreich at once assumed from these symptoms that there was spasm of the ciliary muscle, and in order to ascertain what the state of refraction of the eye really was, paralysed the accommodation by the instillation of a strong solution of atropine; this had, however, to be repeated several times before the muscle was thoroughly paralysed. It was then found that instead of being myopic, the eye was, in fact, hypermetropic, and that the hypermetropia $= \frac{1}{24}$.

The patient was ordered to abstain from working at near objects; the instillation of atropine was continued for some time, in order to remove the spasm; and she was also furnished, for distance, with the convex glasses which neutralized the hypermetropia.

Monocular diplopia and polyopia is sometimes met with in connexion with certain anomalies of accommodation and refraction. We occasionally find it, for instance, in myopia, hypermetropia, or presbyopia; in such cases it shows itself when the person is regarding an object, the rays from which impinge in such a manner upon his eye that he cannot bring them to a focus upon the retina, circles of dispersion are formed upon the latter and give rise to the diplopia. This would occur in a myopic person when he is regarding an object which lies beyond his far point; in a presbyop, when he is looking at an object nearer than his near point.

Monocular diplopia may be also caused by the diffusion of light through opacities in the refracting media, by luxation of the lens, &c.

As there is occasionally a considerable difference between the two eyes, we should always examine the

vision, state of refraction, and range of accommodation of each eye separately. Only in this way can we arrive at the proper course of treatment. When there is a considerable difference in the myopia of the two eyes it appears proper to furnish each eye with the glass suitable to its own amount of short sight, but practically this does not generally answer, for the patients mostly complain that it renders vision confused and indistinct. It may be, therefore, laid down as a practical rule that when any difference exists in the amount of myopia of the two eyes, both should be furnished with the glass which suits the least myopic eye. Arlt thinks that when the sight of the two eyes (differing considerably in the degree of their myopia) is equally good ; the glass which lies midway between the two should be given for both. Thus if one eye requires concave 4, the other concave 8, we should give No. 6. If, however, the sight of both eyes is not the same, we must be guided by the state of refraction of the better eye, and give this glass for both eyes. To such cases it would be advantageous often separately to exercise the worse eye in reading, &c., so that its sight may not suffer by exclusion.

We should never permit the use of single glasses, for whilst the one eye is habitually used, the vision of the other soon deteriorates on account of its disuse, and it may become considerably amblyopic.

We must be careful in choosing spectacles that they fit accurately, that one glass is not higher than the other, that they are sufficiently near the eyes, and that the centre of each glass is exactly opposite the centre of the pupil. The last caution is particularly necessary

in the selection of glasses which fit on to the nose by means of a spring (pinces nez), for they are often not accurately centred, and if they do not fit properly, so that their centre corresponds to the centre of the pupil, they act as prisms, and give rise to strabismus, which may even, if their use is persisted in, become permanent.

Concave glasses should be quite close to the eye, otherwise they will diminish the size and intensity of the retinal image. As the rays impinging upon a concave glass are rendered divergent by it, it follows that the further the glass is removed from the eye the fewer peripheral rays will enter the latter, in consequence of which the retinal image is diminished in size and intensity. The reverse obtains when convex glasses are used, for as they render the rays falling upon them more convergent, a greater number of peripheral rays will enter the eye the further (up to a certain point) the convex glass is removed from it, the retinal image becoming at the same time larger and more luminous.

The proper and scientific choice of spectacles is indeed of great importance to the public; and I have no hesitation in saying that the empirical, hap-hazard plan of selection generally employed by opticians is but too frequently attended by the worst consequences, that eyes are often ruined which might, by scientific and skilful treatment, have been preserved for years. I would, therefore, strongly recommend the adoption of the following plan, which is largely employed on the Continent, and also by several ophthalmologists in England:—The medical man himself selects the proper

glass from his spectacle box* (which contains concave and convex glasses, corresponding number being kept by the optician); the focal distance of the required glass is written on a slip of paper, which is taken to the optician who supplies the patient with the spectacles prescribed thereon. Thus are we sure that the patient is furnished with the proper glasses.

It will have been observed that there are indeed many questions to be considered in the treatment of these affections; and I would strongly impress it upon the reader that, after he has made himself completely conversant with the theoretical portion of this subject, it is only by a thorough practical examination of a number of cases that the requisite facility in the choice of spectacles, the examination of the range of accommodation, &c., can be acquired. To those who consider the views we have propounded as somewhat abstruse and unpractical, I would reply that the apparent difficulties lie but on the surface, and that a little perseverance and practice will soon enable them to unravel the knotty points.

* These boxes, which contain a great number of convex and concave glasses, prisms, coloured glasses, &c., may be obtained of Mr. Pillischer, 88, New Bond-street.

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